WORKBOOK

TO ACCOMPANY

CURTIS, CALDWELL, AND SHERMAN'S

EVERYDAY BIOLOGY

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EVERYDAY BIOLOGY

By

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TO THE TEACHER

To fulfill its functions a workbook for biology should meet these requirements: (1) it should provide abundant and varied activities; (2) it should provide questions to cover adequately the subject matter of the course and thus provide guide sheets to be used with any form of "unit plan" or "contract plan" of teaching.

This workbook seeks to meet the first of these requirements by providing more than a hundred experiments and about forty projects. In addition, it presents a wide variety of activities, such as additional problems, field trips, special reports, correlation of biology with English, book reports, and so on.

It seeks to fulfill the second requirement by including "Guide Questions for Study," covering all the text materials in *Everyday Biology*. These questions are divided into relatively small groups, each of which covers a designated small section of the textbook. These study questions, together with "Questions This Chapter Answers" and the "Self-tests" in the textbook, constitute a program of study helps which is equally valuable for the use of the teacher or the pupil in any plan, method, or procedure by which the work in biology may be conducted.

In constructing the directions for the various activities in this workbook, the authors have endeavored to exemplify the best practices as indicated by authoritative opinions[1] and by research in the teaching of science.[2] To this end they have included many exercises on scientific principles, scientific attitudes, and elements of scientific method; they have reduced to a minimum the number of required representative drawings; they have emphasized function rather than mere structure; they have stressed reflective thinking rather than mere recall of factual information; they have introduced a wide variety of ways of recording the results of activities, in contrast with older practices exemplified in laboratory manuals which emphasized reporting in "story form," and in earlier workbooks which employed chiefly the device of filling blanks with single words; and they have introduced in the "Guide Questions for Study" many exercises giving practice in "How to Study" (see *Everyday Biology*, pp. ix–xi).

The authors have included in this workbook more activities than any pupil or even any class could reasonably be expected to complete. Thus a wide latitude of choice is presented in order to provide not only a selection adequate to serve the individual preferences of the pupils, but also a range of difficulty appropriate to the needs and capabilities of "homogeneous groups" and "activity groups." The most important experiments are designated by asterisks (*).

The activities included in this workbook follow the order of presentation of topics in *Everyday Biology*.

A large proportion of the experiments, projects, and other activities of the workbook require simple apparatus and equipment, and many can be effectively performed by the pupils out of class, at school, or at home.

The *Teachers' Manual* which accompanies *Everyday Biology* contains many suggestions which may be of value to the teacher in connection with each experiment and other activity in this workbook.

FRANCIS D. CURTIS
NINA HENRY SHERMAN

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[1] The Thirty-first Yearbook of the National Society for the Study of Education, Part I. Public School Publishing Company, Bloomington, Illinois, 1932.

Science in General Education, by V. T. Thayer and others. D. Appleton-Century Company, Inc., New York, 1938.

[2] *First, Second, and Third Digests of Investigations in the Teaching of Science*, by Francis D. Curtis. P. Blakiston's on & Co., Inc., Philadelphia, 1926, 1931, and 1939, respectively.

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[1] The pages refer to *Everyday Biology*.

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WORKBOOK

FOR EVERYDAY BIOLOGY

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NAME-- DATE--------------------------

EXPERIMENT 1. THE COMPOUND MICROSCOPE[1]

Problem. What are the important parts of the compound microscope, and how does a scientist use the microscope?

Materials. Compound microscope; microscope slides; cover glasses; piece of newspaper; lens paper.

Procedure and observations. Follow these directions exactly so that you will not injure the microscope and so that you may learn to use the microscope in the most efficient way. Compare your microscope with the figure. Identify all the parts named and note their functions.

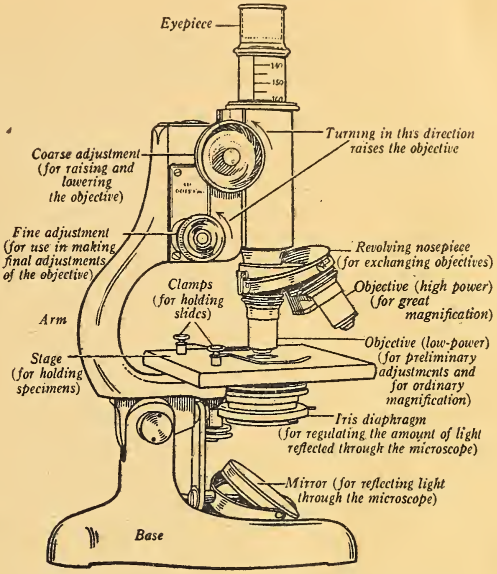
Eyepiece
140
150
160
Coarse adjustment (for raising and lowering the objective)
Turning in this direction raises the objective
Fine adjustment (for use in making final adjustments of the objective)
Revolving nosepiece (for exchanging objectives)
Clamps (for holding slides)
Objective (high power) (for great magnification)
Arm
Objective (low-power) (for preliminary adjustments and for ordinary magnification)
Stage (for holding specimens)
Iris diaphragm (for regulating the amount of light reflected through the microscope)
Mirror (for reflecting light through the microscope)
Base

Fig. 1. Diagram of a compound microscope

Before using the microscope wipe the lenses of the eyepiece and the objectives with lens paper. Never use anything else, as it is likely to scratch and thus ruin the lenses.

Place the microscope before you, with the arm toward you. The low-power objective should be under the tube, with its bottom nearly touching the stage. Now place your eye at the eyepiece and look down into the tube. Use the mirror to throw a beam of light up through the hole in the stage. Sometimes you will secure better lighting by using the flat mirror and at other times by using the concave mirror on the back of the flat mirror. When you can see a clear light space, with no shadows, you are ready to proceed. **[CAUTION. Do not place the microscope in direct sunlight.]**

Make a slide by putting a drop of water on a microscope slide, placing in the water one of the small letters cut from a newspaper page, and covering it with a cover glass. Place the slide on the stage of the microscope, with the letter as nearly under the objective as possible. Make the preliminary adjustments thus: while you watch from one side, turn the coarse-adjustment screw slowly from you. Always make the preliminary adjustments while looking from the side.

You are now ready to make the coarse adjustments. With the low-power objective almost touching the slide, look into the eyepiece with one eye, keeping the other eye open to avoid squinting. Keep your eye there while you slowly raise the objective by turning the screw in the direction indicated in the figure. When you can see part of the letter clearly, you have it in focus.

If you do not secure a satisfactory focus, repeat the entire adjustment from the beginning. Never lower the objective with the coarse adjustment while looking through the eyepiece, as you are likely to punch the objective through the slide.

Move the slide slightly to the left. Does the letter as you see it through the microscope move

to the right or to the left? ------------

Move the slide toward you. In which direction does the letter move? ------------

For most of your observations with the microscope you will use only the low-power objective with coarse adjustments. **[CAUTION. Do not use the fine adjustment with the low-power objective.]**

---

[1] *To the Teacher.* See the earlier section "To the Teacher" (p. ii).

To use the high-power objective first move the slide so that some part of the letter is in the center of the field. Now, without moving any other part, turn the revolving nosepiece around so that the high-power objective is under the tube. Look through the eyepiece, and turn the fine adjustment one-half turn either way. This should bring the letter in focus. If it does not, turn back to the low power and focus again. Never try to find an object under high power.

Make a slide of two or three fibers from the lens paper and examine them in the same way as you did the letter, with both the low-power objective and the high-power objective. Practice the various adjustments until you can perform them easily and with assurance.

FIELD TRIP. SECURING SPECIMENS FOR LATER STUDY[1]

Purpose. To secure insects and other biological materials for later study.

Materials. An insect net; a killing bottle; a few envelopes for the larger insects; an extra box or so, or a jar or bottle for other kinds of animals, as frogs or snakes; a preserving liquid (Formalin), made by adding 4 parts of formaldehyde to 96 parts of water.

Procedure. An insect net can be made of stiff wire, mosquito netting or marquisette, and a broom handle, as in the figure. The hoop should be about a foot in diameter. A killing bottle may be made of a mayonnaise jar or peanut-butter jar in the bottom of which is a piece of cotton soaked in gasoline, chloroform, ether, carbon tetrachloride, or cleaning fluid. **[CAUTION. Avoid inhaling the fumes of any of these liquids, as all are to a considerable extent poisonous.]** Place some pieces of paper above the cotton in the jar to prevent wetting the specimens. For additional suggestions for securing and preserving insects see *Everyday Biology*, pp. 638–639.

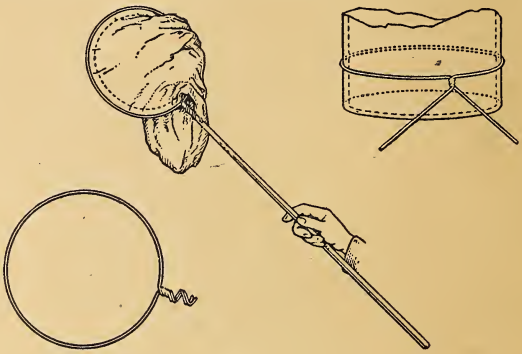

Fig. 2

Be sure to secure a large supply of grasshoppers and many other kinds of insects, such as beetles, crickets, katydids, and the like. You will also want a few spiders. If there is a stream or a pond near by, try to secure frogs and crayfish. Kill all these animals by putting them into the killing bottle. Preserve them in the Formalin solution. The frogs will be more difficult to preserve than the other animals. After they have been placed in the Formalin solution, cut a slit in the body wall to let the preserving fluid into the body. If you cut the slit carefully, you will not injure the internal organs.

Look on the under-side of leaves and branches for cocoons of moths and butterflies. Keep these in a cool place in the basement or out of doors until you are ready to study them.

You will need a supply of earthworms. You will be more likely to secure large specimens by searching after dark with a flashlight on the lawn after it has been thoroughly wet. Keep some of the worms alive by leaving them in a box or flowerpot full of moist earth. Preserve others by dropping them into the Formalin solution. Preserve only perfect specimens.

Keep a record on the next page of the kinds and numbers of specimens which you are contributing to the class for its laboratory studies. Since you will probably not secure all your specimens on the same day, you will find it convenient to record the numbers by marks (𝍸 𝍸 //).

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[1] This field trip should be taken early in the fall while insects and other animals suitable for laboratory study are still to be found. If you live in a great city, you will find specimens in your back yard or in the parks; but you will find more specimens, of course, if you can go out of town into the fields and woods.

Record of Specimens Contributed

LABORATORY EXERCISE
TO LEARN HOW TO MAKE ACCEPTABLE DIAGRAMS, SKETCHES, AND DRAWINGS

Procedure. In connection with the various experiments, projects, and other exercises in this workbook you will be asked to make three types of picture representations: diagrams, sketches, and drawings. A *diagram* represents an idea rather than an object. It shows how an apparatus is set up, as in Fig. 3, or it shows the important steps in a process, as in Fig. 4. The diagram is not intended to give an accurate idea of size or shape, but merely to show at a glance what the essential parts or processes are and how they are related.

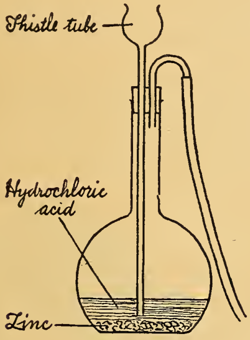


Fig. 3

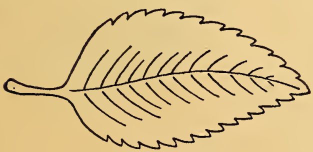


Fig. 5

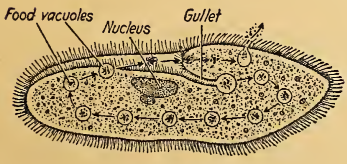


Fig. 6

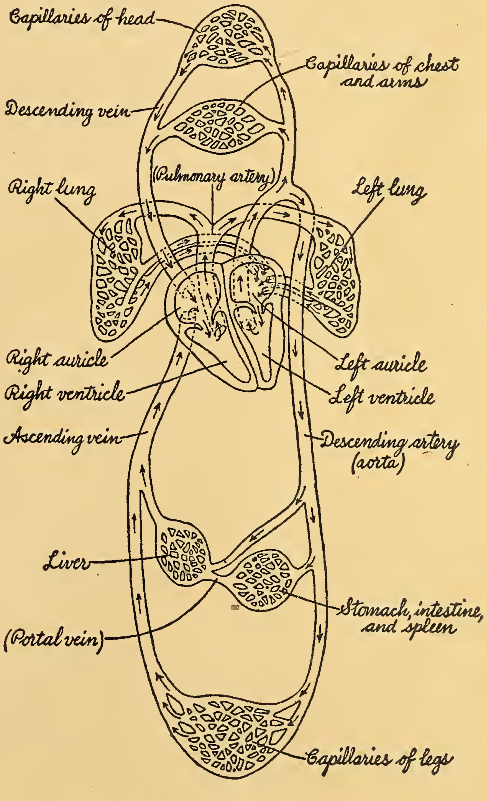


Fig. 4

A *sketch* is intended to represent in outline a typical object of a certain kind, but not any individual object more than others of its kind. Thus the sketch gives the general shape and approximately the relative sizes, shapes, and locations of the important structures you want to show, but omits all other details. Fig. 5 is a sketch intended to show a few of the important structures of an elm leaf, but it represents no particular elm leaf. Also, all details are omitted except the structures which the sketch is intended to include.

A *drawing* is intended to show in outline the exact shapes and relative positions of structures in some particular specimen. It is usually drawn from observations through a microscope and hence is greatly enlarged. Fig. 6 is a drawing of a microscopic animal (*Paramecium*) which you will study many times in *Everyday Biology*. Much time and great pains are required in making a laboratory drawing.

Of these three types of picture representations the sketches and the diagrams are more useful than the drawings and will be required much more frequently.

The following steps should be followed in order in making any of these three types of picture representations:

1. *Laying out the diagram, sketch, or drawing.* The "picture" or series of "pictures" should be planned to fill the space available so as to present an attractive appearance. A small "picture" in a large space or in only one corner of a space is undesirable.

2. *Estimating the size.* Make the representation sufficiently large to show clearly whatever it is that you wish to represent. Most pupils have a tendency to crowd their "pictures" or to make them too small. Be sure to leave sufficient space at the sides for the necessary labels.

3. *Outlining the "picture."* First measure roughly with your eye or with a pencil or ruler the object you wish to represent, so that you will have a clear idea of the proportions of the parts. With a soft pencil lightly sketch the general outline. You may need to erase more or less before you have a satisfactory outline.

4. *Finishing the "picture."* With a *hard* pencil trace the final outlines in a firm, continuous line. Erase all extra lines, if there are any.

5. *Adding the labels.* With a ruler or other straightedge draw a line from each part which you wish to label to the space in which you intend to write the label. It is always better to draw these lines before you write the labels, to prevent crowding and to ensure neatness. Write or print the labels neatly in horizontal lines. Make each line touch the part of the "picture" which the label names. Do not draw arrows for label lines, since arrows are intended to represent directions in which objects or forces move.

6. *Adding the title.* Write beneath the "picture" a word or a few words to indicate what is represented.

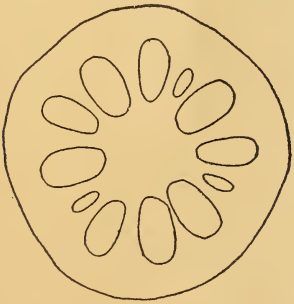


Fig. 7. Diagram to show location of fibrovascular bundles of a young dicot stem

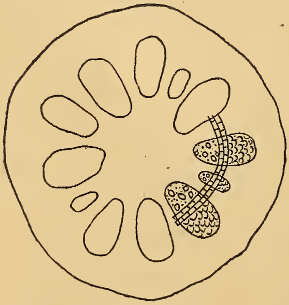


Fig. 8. Sketch to show shape of bundles and relation of parts

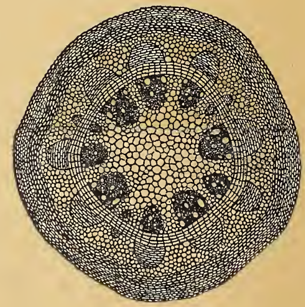


Fig. 9. Drawing of a young dicot stem

Shading and even coloring may sometimes be desirable in a diagram, but should very rarely be used in a drawing or a sketch.

Why is Fig. 7 an acceptable diagram but not an acceptable sketch or drawing?

Why is Fig. 8 an acceptable sketch but not an acceptable drawing?

What characteristics of Fig. 9 show clearly that it is a drawing and not a sketch?

LABORATORY EXERCISE

TO FOLLOW DIRECTIONS IN MAKING A DIAGRAM, A SKETCH, AND A DRAWING

Materials. Moth wing; microscope; slides; soft pencil; hard pencil.

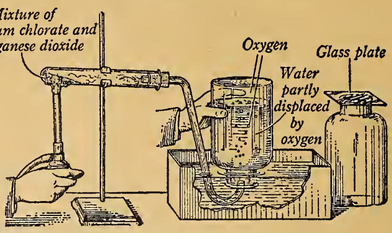
Procedure. Make a diagram of your biology room as if seen from the ceiling. Indicate the number and relative positions of chairs or stools, tables, sinks, and the like. Or make a diagram which might serve a stranger in finding his way from the school to your home.

Examine the moth wing under the microscope; then draw a sketch showing how the tiny "feathers" are arranged, that is, whether they overlap or not. Remember that a sketch need show only the features which it is expected to show; all else may be omitted from the sketch.

Next make a drawing of one of the moth "feathers."

NAME____ DATE_________________

EXPERIMENT 2. OXYGEN[1]


Mixture of potassium chlorate and manganese dioxide
Oxygen
Glass plate
Water partly displaced by oxygen

Problem. What are some of the characteristics of oxygen?

Materials. Pure potassium chlorate; manganese dioxide; test tube; stand; burner; pneumatic trough or sink; glass bottles; glass plates; wooden splint; glass tubing.

Procedure and observations. Mix thoroughly three parts of potassium chlorate and one part of manganese dioxide which is thoroughly dry. **[CAUTION. Do not grind, because of the danger of causing an explosion.]** Arrange the apparatus as in the figure. Heat the mixture in the test tube by gently passing the flame back and forth over the test tube. After the gas has escaped from the tube for a few seconds, collect two or three bottles of it. Thrust a glowing wooden splint into one bottle of oxygen.

Does the splint flame up, or is the glowing coal extinguished?

Summarize in a statement all the facts you have learned about oxygen in this experiment.

EXPERIMENT 3. CARBON DIOXIDE[1]

Problem. What are some of the characteristics of carbon dioxide?

Materials. Baking soda; an acid, such as hydrochloric acid, vinegar, or lemon juice; clear limewater; glass rod; tumbler.

Procedure and observations. Place about a tablespoon of soda in the tumbler. Add enough acid to cause violent effervescence, or bubbling. The gas formed is carbon dioxide. After a few seconds note the color of the carbon dioxide in the top of the tumbler.

What is this color?____

When the effervescence stops, dip the glass rod into limewater; then immediately thrust the wet end of the rod into the carbon dioxide in the tumbler.

What color does the limewater on the rod become? __________

Thrust a glowing splint into the carbon dioxide. What happens?

Summarize in a statement all the facts you have learned about carbon dioxide.

---

[1] *To the Teacher.* These experiments are included so that they may be available in case they have not been performed in a previous course in science, or in case it should be desirable to review them.

GUIDE QUESTIONS FOR STUDY. FACTORS AND CONDITIONS AFFECTING LIFE

[Text pages 14–21]

1. Which of the following factors and conditions affecting life are directly necessary to all living things: food, heat, light, oxygen, carbon dioxide, water, shelter, soil, other living things, weather, climate, physiographic features?

2. What is meant by the statement that all life can exist only within a rather limited range of temperature?

3. Name an animal which can live only in fresh water. ____________________

Name another which can live only in salt water. ____________________

Name another which can live in either salt water or fresh water. ____________________

GUIDE QUESTIONS FOR STUDY. FACTORS AND CONDITIONS AFFECTING LIFE

[Text pages 21–27]

1. Name one or more living things which cannot survive if the following factors and conditions are varied greatly from the amount or degree to which the living things are accustomed:

(1) *Food* ____________________

(2) *Heat* ____________________

(3) *Light* ____________________

(4) *Oxygen* ____________________

(5) *Carbon dioxide* ____________________

(6) *Weather* ____________________

(7) *Climate* ____________________

(8) *Water* ____________________

(9) *Shelter* ____________________

(10) *Soil* ____________________

2. In earlier ages certain areas which are now dry were swampy. What was necessary for the plants and animals to do in order to survive in these regions while the climate and the environment in general were slowly changing?

3. Name six or more different kinds of shelter which various living things use. Give an example of some living thing using each kind.

4. What kinds of land formations or bodies of water would tend to confine these living things within certain regions?

(1) *Wolf*

(2) *Song bird*

(3) *Frog*

(4) *Lawn grass*

(5) *Maple tree*

(6) *Butterfly*

5. Compare the symbiotic relationship of a hermit crab and a hydroid growing on the crab's shell, with the parasitic relationship of a dog and a flea living in the dog's fur. (See "How to Study," p. x of *Everyday Biology.*)

SIMILARITIES	DIFFERENCES

6. How many ways can you name in which plants furnish shelter to other animals and plants?

7. What factors and conditions necessary to the life of a goldfish are present and which are not present in the habitat of deep-sea fish?

8. Name animals and plants which live in these environments:

(1) *Water*

(2) *Mountains*

(3) *Desert*

(4) *Swamps*

(5) *Jungles*

(6) *Arctic regions*

(7) *Plains*

Self-test on Biological Terms. Be sure you can define these words. Check your definitions with those in the Glossary of your textbook.

biology energy fossil habitat parasite symbiosis

Exercise on Biological Principles. Examine the list of biological principles on pages 626–627 of *Everyday Biology.* Write here one that you think relates to the materials you have just studied in Chapter II of *Everyday Biology.*

NAME________________________________ DATE________________

*EXPERIMENT 4.[1] STUDY OF A LIVING CELL (ONION)

Problem. What are some of the characteristics of an onion cell?

Materials. An onion; a knife; microscope; microscope slides and cover glasses; weak tincture of iodine or a solution of iodine crystals in water.

Procedure and observations. Remove some of the outside layers from the onion. Then with the knife peel off some of the thin skin from the inside of one of the layers. Mount this thin skin in water on a microscope slide and cover it with a cover glass. Examine it under the low power of the microscope. Note carefully the shapes and comparative sizes of the cells. In the space below make a careful drawing of three or four of the cells you see. Add to the material on the slide a drop of the iodine solution. If you now see any structures which you did not see before, add them to your drawing. Now study the cells under the high-power objective. Compare the cell you are observing with the figure. (See "How to Study," p. x of *Everyday Biology*.)

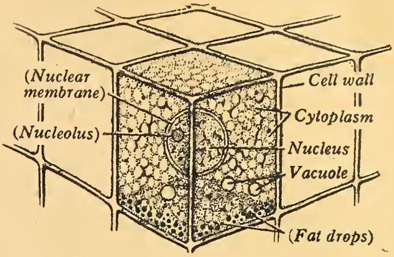


Fig. 1

SIMILARITIES	DIFFERENCES

In the space below make a drawing of one of the cells as you observe it under high power. Label all the structures you can identify as similar to structures shown on this page.

---

[1] *To the Teacher.* Experiments designated by an asterisk (*) represent minimum essentials. They should all be performed individually by the pupils or demonstrated before the class.

EXPERIMENT 5 (OPTIONAL).[1] STUDY OF LIVING CELLS (GREEN CELLS)

Problem. What similarities and what differences are there between cells of *Elodea* or a moss leaf and those of the onion?

Materials. *Elodea*; moss plant; microscope; slides and cover glasses.

Procedure and observations. Remove a young leaf from an Elodea plant or from the tip of a moss plant, and mount it in water. Examine it under both low-power and high-power objectives. Note the shapes and sizes of the cells which make up the leaf. Note the characteristics of any colored bodies which you see. These are chloroplasts, which will be discussed later in Unit II of the textbook. You may have difficulty in finding the nucleus, since it is colorless.

Is there any movement of the cytoplasm? ____
Describe what you see.

Draw in the space below one of the cells you have been observing, as you see it under high power. Label all the structures you can identify.

Conclusion. Answer the question asked in the problem at the beginning of this experiment.

EXPERIMENT 6 (OPTIONAL). FURTHER STUDY OF LIVING CELLS

Problem. What are some of the characteristics of some other cells than those of onion and *Elodea*?

Materials. Epithelial cells from the mouth; young geranium leaf; young squash seedling; microscope; slides and cover glasses.

Procedure and observations. In the same way that you made the slides for Experiments 4 and 5 make slides of the epithelial cells from the mouth (obtained by scraping the inside of the cheek with a toothpick), the tip or edge of a young geranium leaf, or the hairs on the stem of a young squash seedling.

Make labeled drawings to show what you observe.

General conclusion. Write a brief description, consisting of a sentence or two, of the general characteristics of a living cell as you have observed it.

---

[1] *To the Teacher.* An experiment designated as "Optional" is intended for the pupils who wish to perform "extra" experiments.

GUIDE QUESTIONS FOR STUDY. CELLS
[Text pages 29–35]

1. Name the characteristics of protoplasm.

2. Draw a line from each definition in the first column to the function of protoplasm which it defines in the second column.

Producing others of its kind	*Respiration*
Securing food energy	*Nutrition*
Getting rid of waste products	*Excretion*
Breathing and using oxygen	*Reproduction*
Responding to light, sounds, and so on	*Irritability*

3. What characteristics are possessed by all living cells?

By all tissues?

By all organs?

4. State in one sentence a definition of *cell.*

5. What is the *cell theory*?

GUIDE QUESTIONS FOR STUDY. LIVING AND NONLIVING MATTER
[Text pages 36–42]

1. Contrast living and nonliving things by giving characteristics of living things which nonliving things do not possess.

2. Give three or more examples of an element, of a compound, and of a mixture.

(1) *Element*

(2) *Compound*

(3) *Mixture*

3. Give three examples of an organic substance and also three examples of an inorganic substance.

(1) *Organic substance*

(2) *Inorganic substance*

4. A convenient means of remembering the names of the chief elements found in protoplasm is to memorize CHONS, which is composed of the first letters of the names of the elements. What are these elements?

Rearrange the letters in CHONS so as to indicate the order of relative abundance of the elements in protoplasm.

Exercise on Biological Principles. Examine the list of biological principles on pages 626–627 of *Everyday Biology.* Write here one or more that you think relate to the materials you have just studied in Chapter III of *Everyday Biology.*

*EXPERIMENT 7. OSMOSIS

Problem. What happens when two different liquids are separated by a moist membrane?

Materials. Thistle tube with stem bent as in Fig. 2; two glass beakers; support stand; water; molasses; animal membrane, such as parchment or pig's bladder.

Procedure and observations. Fill with molasses the bulb of the thistle tube. Meanwhile keep your finger over the end of the tube, so that the air in the tube will keep the molasses confined as much as possible to the bulb. Tie the animal membrane tightly over the top of the thistle tube, so that no water can enter the bulb around the edges of the membrane. Set up the apparatus as in Fig. 2. Taste the water which you put into the beaker. Taste also the molasses. Allow the apparatus to stand until the next day or for two or three days. Taste the liquid.

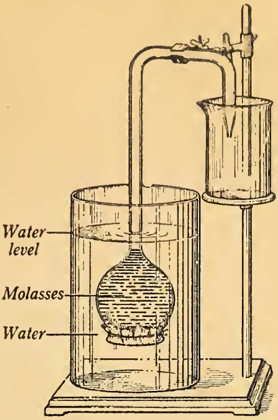


Fig. 2

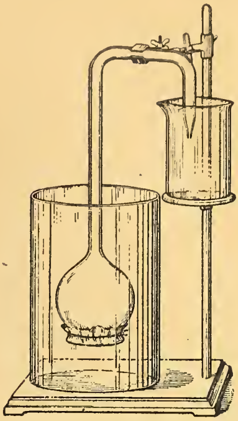


Fig. 3

Conclusions. Record your observations by completing Fig. 3. Add the three labels indicated in Fig. 2, and add labels or lines or both at other points, if necessary, in order to indicate all changes which have occurred.

Discussion. After reading pages 43–45 of the textbook explain fully what occurred in this experiment and why it occurred.

EXPERIMENT 8 (OPTIONAL). OSMOSIS

Problem. How high will water rise in the tube of a simple osmosis apparatus?

Materials. Thistle tube; glass beaker; long glass tube; short length of rubber tubing for connecting the thistle tube and the glass tube; animal membrane; molasses; water.

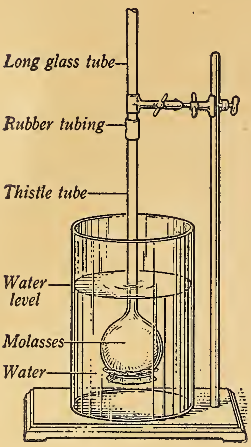


Fig. 4

Procedure and observations. Set up the apparatus as in Fig. 4. Allow the apparatus to remain for several days, noting meanwhile all changes that occur.

Conclusions. Indicate on Fig. 4 the water levels in the tube at different times; as, "Water level after 6 hours," "Water level after 2 days," and so on. The membrane will probably break after two days or less.

EXPERIMENT 9 (OPTIONAL). REVERSE OSMOSIS

Problem. In osmosis does the liquid always pass in the same direction through a membrane?

Materials. Two thistle tubes; 2 beakers; 2 support stands; animal membranes, such as pig's bladder or "osmosis membranes"; water; molasses.

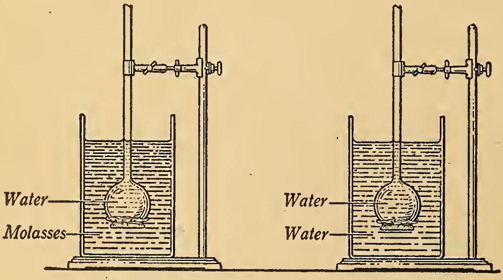


Fig. 5

Procedure and observations. Set up the apparatus in the same way as in Fig. 5. Partly fill both thistle tubes with water, and tie the membranes over the ends of the thistle tubes. Put the molasses in one beaker; put an equal amount of water in the other. Now place one thistle tube in each beaker, and support the tubes in such a position that the level of the liquid in the thistle tubes is the same as that in the beakers. Let the apparatus stand until the following day. What has happened to the level of the water in the thistle tubes?

Conclusions. Describe briefly what occurred in this experiment. Explain why this happened.

Exercise on Scientific Method (Using Controls and Making Inferences [1]). Read carefully the "Elements of Scientific Method" on page 625 of *Everyday Biology.*

1. In Experiments 7 and 9 the second set of apparatus serves as a control. Can you explain why these controls were necessary?

2. Can you infer from Experiment 9 why putting salt on grass kills the grass?

---

[1] For definition of *control* and *inference* consult the Glossary of *Everyday Biology.*

NAME________________________________ DATE________________

GUIDE QUESTIONS FOR STUDY. PHYSICAL AND CHEMICAL CHANGES

[Text pages 42–46]

1. Compare the oxidation of food in the cells of the body with the oxidation of coal in a furnace. (See "How to Study," p. x of *Everyday Biology.*)

SIMILARITIES	DIFFERENCES

2. Give an original example of physical change.

Of chemical change.

Self-test on Biological Terms. Be sure you can define these terms. Check your definitions with those in the Glossary of your textbook or in a dictionary.

cell
cell theory
chemical change
compound
element
inorganic
molecule
nucleus
organ
organic
osmosis
oxidation
physical change
protoplasm
tissue
vacuole

GUIDE QUESTIONS FOR STUDY. THE STRUGGLE FOR SURVIVAL

[Text pages 47–57]

1. What is meant by "a constant struggle for survival"?

2. Why is the struggle for survival necessary?

3. Give an example, original if possible, illustrating the energy cycle.

4. Give an example, original if possible, illustrating the matter cycle.

5. Give one or more examples of

(1) *Dependent plant* ________________________________

(2) *Plant parasite* ________________________________

(3) *Animal parasite* ________________________________

(4) *Independent plant* ________________________________

(5) *Saprophyte* ________________________________

(6) *Dependent animal* ________________________________

6. Give an example of a complex organism, and explain how it is complex.

7. Give an example, preferably an original one, which illustrates division of labor.

NAME-- DATE------------------

*EXPERIMENT 10. THE PARTS OF A FLOWER

Problem. How do the parts of a typical flower illustrate division of labor?

Materials. Flowers of several different kinds, such as violet, buttercup, morning-glory, lily, apple, tulip, daffodil, narcissus, hyacinth, and lily of the valley.

Procedure and observations. Record in the table on page 21 the facts which you observe concerning each specimen. Consult Fig. 1 and, if necessary, the Glossary of your textbook in order to identify the various flower structures.

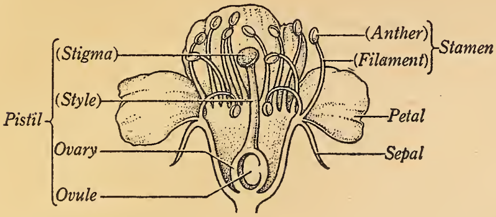


Fig. 1

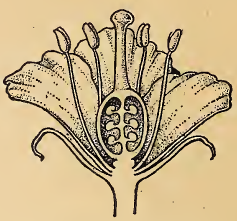


Fig. 2

Label the parts of Fig. 2 with the numbers of the following statements, which describe the functions of the parts. For example, you would write 1 at the end of a line leading from the anther of the stamen, to indicate that the pollen ripens in the anther of the stamen. Fig. 1 will help you to locate the parts.

1. The structure in which the pollen ripens.
2. The structure in which the seeds develop.
3. The structures which serve to protect the reproductive parts of the flower, especially during the time that the bud is developing.
4. The structure upon which mature pollen grains stick and upon which they grow.
5. The structure in which the embryo plant develops.
6. The structure through which the tube from the developing pollen grows toward the ovule.

What parts of the flower are necessary for the production of seeds?

Which of these flowers that you have studied are complete and which are perfect? (See the Glossary of *Everyday Biology.*) Explain the difference between complete flowers and perfect flowers.

Name of Flower	Number of Sepals in Calyx	Number of Petals in Corolla	Petals Joined or Separate	Sepals Joined or Separate	Number of Stamens	Number of Pistils

Exercise on Scientific Principles. How do the parts of a flower illustrate the principle "The more complex an organism is, the greater is the division of labor"?

PROJECT 1. TO MAKE AN AQUARIUM

Procedure. Follow the directions given in detail on pages 636–638 of *Everyday Biology*.

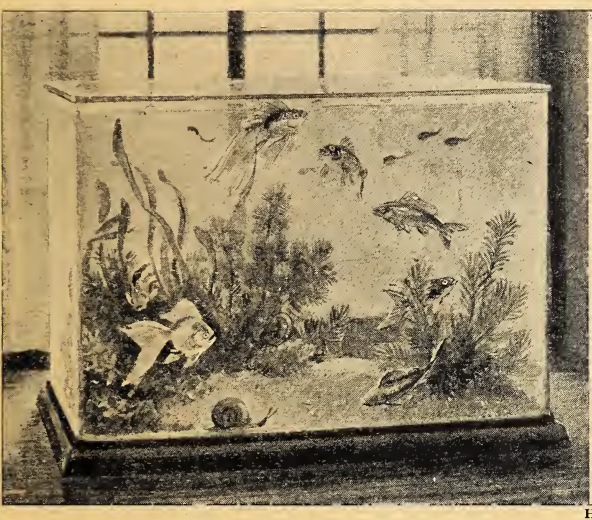
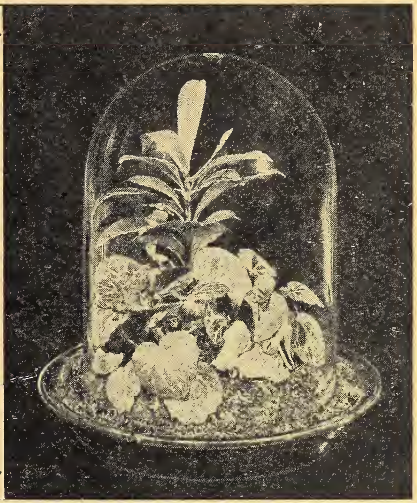


Fig. 3



Hedrich-Blessing Studio from *Better Homes and Gardens Magazine*

Fig. 4

PROJECT 2. TO MAKE A TERRARIUM

Procedure. Follow the directions given in detail on page 645 of *Everyday Biology*. Record here any unusual or especially interesting observations that you make in connection with the terrarium.

GUIDE QUESTIONS FOR STUDY. THE STRUGGLE FOR SURVIVAL

[Text pages 58–61]

1. Give two or more examples of each of the kinds of enemies described on page 58 of the textbook.

(1)

(2)

(3)

(4)

2. List several kinds of protective adaptations of plants.

3. Give an example, preferably an original one, of each of the types of protective adaptations of animals.

ADAPTATION	EXAMPLE
Offense or defense	*Crayfish claws*
Skin	

GUIDE QUESTIONS FOR STUDY. THE BALANCE OF NATURE

[Text pages 61–67]

1. What is meant by "balance of nature"?

2. What is likely to happen when a new plant or animal is introduced into a new habitat?

3. Give an example of each of the ways, discussed in the textbook, in which man upsets the balance of nature.

4. List ways in which man attempts to restore the balance of nature.

Self-test on Biological Terms. Be sure you can define these words. Check your definitions with those in the Glossary of your textbook.

adaptation
balance of nature
dependent organism
division of labor
energy cycle
habitat
independent organism
matter cycle
parasite
protective resemblance
saprophyte

Exercise on Biological Principles. Examine the list of biological principles on pages 626–627 of *Everyday Biology*. Write here one or more which you think apply to the materials you have just studied.

NAME________________________________ DATE________________

*EXPERIMENT 11. HELIOTROPISM

Problem. Do plant stems tend to grow toward or away from light?

Materials. Two small potted plants of the same kind and as nearly alike as possible; two boxes of the same kind, such as shoe boxes, large enough to cover the plant.

Procedure and observations. Cut two openings of the same size in opposite sides of the two boxes. Place one plant in each box, and place both boxes in equal lighting in a window (Fig. 1). Keep the boxes closed, except when watering the plants. Do not change the positions of the plants. After a week or so the plants should indicate the answer to the problem. Indicate the answer by means of sketches of the two plants as they now appear.

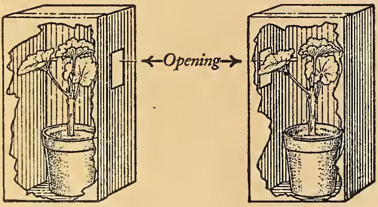


Fig. 1

PROJECT 3. TO FIND EXAMPLES OF MANY DIFFERENT TYPES OF LEAF MARGINS

Procedure. Study the margins of leaves of a considerable number of trees, bushes, flowering plants, grasses, and the like.

Fig. 2 shows some common types of leaf margins.

In the spaces which follow write beside the name of each of the plants, the leaf margins of which are shown in Fig. 2, the names of other plants having similar leaf margins.

(1) *Solomon's seal* ________________________________

(2) *Elm* ________________________________

(3) *Geranium* ________________________________

(4) *Cottonwood* ________________________________

(5) *Red oak* ________________________________

(6) *White oak* ________________________________

(7) *Walnut* ________________________________

(8) *Honey locust* ________________________________

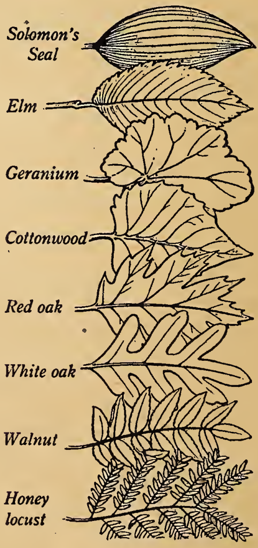


Fig. 2

GUIDE QUESTIONS FOR STUDY. ADAPTATIONS OF PLANTS

[Text pages 70–78]

1. Are the leaves at the tips of branches larger or smaller than leaves farther from the tip? Explain.

2. List at least eight adaptations which enable plants to expose to the light a maximum of leaf surface. For example, one such adaptation is spiral arrangement of leaves.

(1) --

(2) --

(3) --

(4) --

(5) --

(6) --

(7) --

(8) --

(9) --

(10) --

3. Why is it important for green plants to present as much leaf surface as possible to the sunshine? (See pages 70–71 of the textbook.)

4. What is the difference between a deciduous tree and an evergreen tree?

5. Why are dandelion plants on the lawn often able to kill more desirable plants?

Additional Problem. From your observations make a list of trees, shrubs, and other plants which have spiral (alternate) and those which have opposite leaf arrangements.

Spiral	Opposite
(1) ----------------------------------	(1) ----------------------------------
(2) ----------------------------------	(2) ----------------------------------
(3) ----------------------------------	(3) ----------------------------------
(4) ----------------------------------	(4) ----------------------------------
(5) ----------------------------------	(5) ----------------------------------
(6) ----------------------------------	(6) ----------------------------------
(7) ----------------------------------	(7) ----------------------------------
(8) ----------------------------------	(8) ----------------------------------

*EXPERIMENT 17. PHOTOSYNTHESIS

Problem. Is more food produced in green leaves when they are placed in bright sunlight or when they are in darkness?

Materials. Two similar potted plants, such as geranium, begonia, or coleus; a pail or other opaque cover, slightly larger than the pot and the plant; beakers; alcohol; iodine solution; warm water.

Procedure and observations. Place the two plants side by side in bright sunlight. Cover one plant with the pail or other covering that will completely exclude light, as in the figure. After several hours remove some leaves from each plant. Mark the leaves so that you will know from which plant each came. Place all the leaves in a beaker half full of alcohol, and then place the beaker in hot, but not boiling, water. The warm alcohol will remove the chlorophyll from the leaves. When the leaves are much lighter in color, remove them from the alcohol and place them in water to which several drops of iodine solution have been added. If starch is present, a blue-black or purple color will appear.

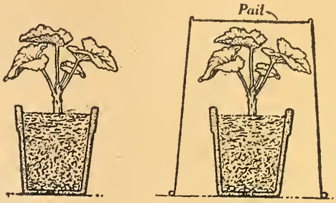


Fig. 5

Conclusion. Answer with a complete sentence the question asked in the problem.

Exercise on Scientific Method (Using Controls and Isolating the Experimental Factor)[1]

1. What conditions were the same with all leaves on both plants?

2. What condition was different with the two plants?

This was the experimental factor.

3. How did the leaves on the plant which was kept in darkness serve as controls?

4. Why was it better experimental practice to use several leaves from each plant rather than only one?

*EXPERIMENT 18. PHOTOSYNTHESIS

Problem. Are portions of leaves which do not contain chlorophyll able to manufacture starch?

Materials. A plant with variegated leaves, such as coleus (or a foliage plant) or variegated geranium; alcohol; beakers; warm water; iodine solution.

---

[1] For definitions of *control* and *experimental factor* consult the Glossary of *Everyday Biology.*

Procedure and observations. Place the plant in bright sunlight for several hours. Remove some of the leaves. Make sketches that will show which portions of the leaves are green and which are white. Then remove the chlorophyll, and test the leaves for starch.

Do the white parts of the leaf, which contain no chlorophyll, show the presence of starch?

------------ Do the green parts show the presence of starch? ------------

Conclusion. What conclusion can you draw from this experiment?

Exercise on the Scientific Attitudes [1]

1. Why was it better to experiment with several leaves than with only one?

2. Which of the scientific attitudes supports your statement?

*EXPERIMENT 19. PHOTOSYNTHESIS

Problem. Does a green plant when placed in sunlight give off a gas? If so, can you determine what the gas is?

Materials. *Elodea* or other water plant; 2 jars; 2 funnels; 2 test tubes; a pail or other opaque cover, slightly larger than the jars; water; carbon dioxide generator.

Procedure and observations. Select vigorous water plants of the same kind and as nearly alike as possible. Fill two jars with water to the same depth in each. Set up a carbon dioxide generator as in Fig. 6. Allow carbon dioxide to bubble for five minutes into the water in each jar. Then place a plant in each jar, and cover each with a funnel. Over the top of each funnel place a test tube as in Fig. 7. Cover one of the jars completely with a pail or black cloth, so that it is entirely in the dark. Place both jars side by side in the bright sunlight. After several hours examine the test tubes over each plant to see whether either or both contain a gas. Test for oxygen and carbon dioxide as directed in Experiments 2 and 3 on page 8 of this workbook.

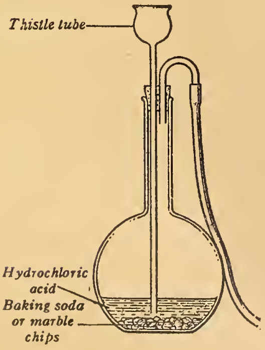


Fig. 6

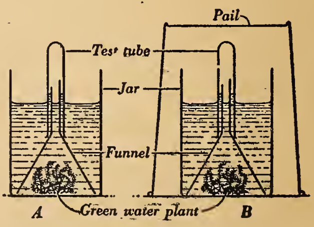


Fig. 7

Repeat the entire experiment, except that you expose the plant in vessel *B* to the sunlight and put the plant in vessel *A* in the dark. This is a check experiment.

---

[1] See *Everyday Biology*, pp. 624–625.

Conclusion. Answer with a complete sentence the two questions asked at the beginning of this experiment.

Exercise on Scientific Method (Using a Check Experiment). What was the value of the check experiment?

PROJECT 5. TO ILLUSTRATE THE OXYGEN–CARBON DIOXIDE CYCLE

Procedure. The figure on page 86 of *Everyday Biology* was drawn by a high-school student of biology. Can you make a drawing illustrating the oxygen–carbon dioxide cycle, using for your living things the animals in an aquarium?

GUIDE QUESTIONS FOR STUDY. PHOTOSYNTHESIS

[Text pages 79–87]

1. Why would a plant starve if too many of its leaves were removed?

2. Name and describe the leaf structures in order from upper epidermis to lower epidermis.

3. Stomata permit air to enter and to pass out of the leaves. Why is it necessary for air to pass in and out?

4. How do the guard cells open and close the stomata?

5. Why do plants carry on food-making only in the presence of light?

6. Complete the following outline, comparing a green plant to a factory:

(1) *The location of the factory?* ____________________

(2) *The rooms where the machinery is located?* ____________________

(3) *The machinery?* ____________________

(4) *The source of energy?* ____________________

(5) *The raw materials needed?* ____________________

(6) *The sources of these materials?* ____________________

(7) *The principal product?* ____________________

(8) *The waste product?* ____________________

(9) *The transportation system?* ____________________

(10) *The form in which the product is transported?* ____________________

(11) *The form in which the product is stored?* ____________________

7. What two products needed by all living things result from photosynthesis?

Problem. Does water pass up through the stem and out of the leaves of a green plant?

Materials. Bottle with two-hole rubber stopper; leafy plant having a stem slightly larger than the holes in the rubber stopper; flask; bent siphon tube; water; cork-borer or glass tube slightly larger than the plant stem; large sheet of cellophane.

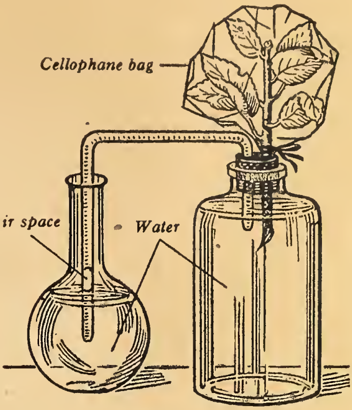


Fig. 8

Procedure and observations. Thrust the cork borer or the glass tube through one of the holes of the stopper, beginning at the bottom of the stopper. Then insert the plant stem into the cork-borer or the tube from the top of the stopper. Now remove the cork-borer or the glass tube, leaving the plant stem firmly fitted into the hole of the stopper. Tie the cellophane around the plant. Insert the siphon tube in the other hole of the stopper, as in the figure. Fill the bottle entirely full of water, and force in the stopper tightly enough so that some of the water is forced through the tube, almost but not quite to the end of the longer arm of the tube. Leave a small air space between the water in the tube and the water in the flask. Watch the air space in the tube. Select from the following endings the one which correctly describes what happens, and underline it:

The air bubble (1) moves upward in the tube and toward the bottle; (2) remains about where it is; (3) increases greatly in size; (4) diminishes greatly in size; (5) escapes from the tube into the flask.

Now lift the tube from the flask so as to admit a little air into the long arm of the tube. Before replacing the tube in the flask, strip all the leaves from the plant stem. Replace the tube in the water in the flask. The apparatus will now look as in the figure, except that the plant will have no leaves. Underline the ending which correctly describes your observations:

The air bubble (1) moves upward in the tube and toward the bottle; (2) remains about where it is; (3) increases greatly in size; (4) diminishes greatly in size; (5) escapes from the tube into the flask.

Conclusion. Answer with a complete sentence the question asked in the problem.

Exercise on Scientific Method

1. What purpose was served by the cellophane bag?

2. Why was it necessary to repeat the experiment, with the leaves removed from the plant?

3. The plant when stripped of its leaves served as a control. Explain.

4. Which of the elements of scientific method listed on pages 624–625 of *Everyday Biology* is represented by this step in the procedure?

EXPERIMENT 21 (OPTIONAL). TRANSPIRATION

Problem. Does water pass up through the stem and out of the leaves of a green plant?

Materials. Two small potted plants of the same kind and exactly alike as nearly as possible; two large sheets of cellophane; cord.

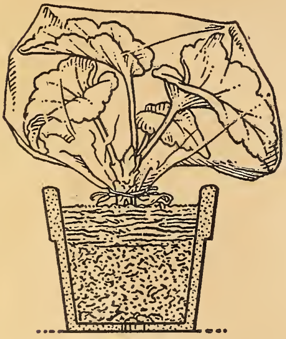


Fig. 9

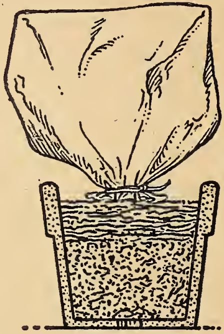


Fig. 10

Procedure and observations. Strip all the leaves from one plant as a control; then tie cellophane in the form of a bag around each plant. After an hour or so can you observe any water on the inside surface of either cellophane bag?

Conclusion. Indicate your answer to the problem by adding to the diagram, with proper labeling, the facts you observed.

Exercise on Scientific Method (Inventing Experiments)

1. Can you invent and carry out an experiment by which to determine whether transpiration takes place more rapidly at night than during the day? Write here the steps in your experiment.

*EXPERIMENT 23. MONOCOT-STEM STRUCTURE

Problem. What is the structure of a monocot stem?

Materials. Cornstalks, corn seedlings, or stems of tulip or lily; knife; slides; microscope; prepared slides, if available.

Procedure and observations. Cut thin sections of the stem, and hold one up to the light. Are the fibrovascular bundles (the denser groups of cells) arranged in a circle or scattered irregularly through the stem?

Place the section on a slide, and examine it under the microscope. Identify by means of the figure on the preceding page the structures you observe. In the space below make a careful drawing of one of the bundles.

GUIDE QUESTIONS FOR STUDY. STEMS

[Text pages 94–100]

In the chart below list the tissues you observed in each kind of stem, and give the function of each.

	TISSUES	FUNCTIONS
Dicot		
Monocot		

EXPERIMENT 24. LOCATION OF BUDS

Problem. Where are buds located on a stem?

Materials. Twigs of several different kinds bearing buds. Horse-chestnut, cottonwood, hickory, and lilac twigs are good materials for this experiment.

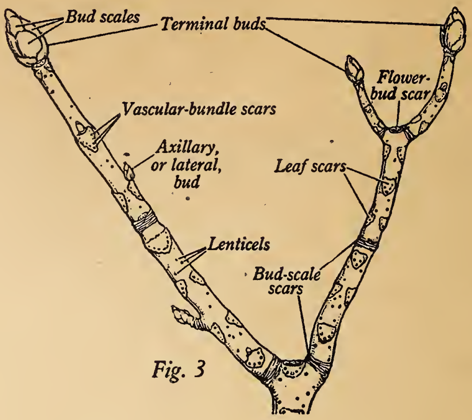


Fig. 3

Procedure and observations. Note the buds (terminal buds) at the ends of the twigs. Do you also find buds (axillary buds) along the stem just above the place where a leaf was attached?

____________ Note the shape and the position of the leaf scars. Find a place where numerous small scars form a circle around the stem. These are bud-scale scars. They show where a new year's growth began. How many such rings of growth can you find? ____________ How old, then, is your twig?

Conclusions. In the space opposite Fig. 3 make an outline sketch of the twig you are studying. Show and label terminal buds, axillary buds, leaf scars, and bud-scale scars.

EXPERIMENT 25. THE STRUCTURE OF A BUD

Problem. What is the structure of a bud?

Materials. Any rather large leaf buds, preferably of several kinds [1]; flower buds, if available; hand lens.

Procedure and observations. Select some twigs having dormant buds, and others having buds that are starting to open. Remove the bud scales from one bud. In what ways do they seem to protect the parts beneath them?

Cut another bud open longitudinally. Examine the cut surface with a hand lens. What structures can you recognize?

---

[1] If this study is made in the late winter or in the spring, abundant material may be collected out of doors. If the study is made in the autumn or early winter, illustrations may be secured from a greenhouse or by keeping dormant buds of trees or shrubs in water in the classroom

Compare the structures you find in this bud with those found in a bud that has opened and started to grow. What changes in a bud take place in the process of growth?

Have any new structures developed as the bud has grown, or were all the parts present in the unopened bud?

Cut open other buds. Are any of them mixed buds, that is, buds containing both flowers and leaves? ____________

If you have any unopened flower buds, study them in the same way. Compare the parts of the bud with the parts of an opened flower. What parts of the flower do you find present in the unopened bud?

Conclusions. Draw sketches to show the structures of the different kinds of buds you examined.

EXPERIMENT 26 (OPTIONAL). ANNUAL RINGS

Problem. Are the different portions of a tree branch of different ages?

Materials. Tree branch about three feet long; knife; saw; sandpaper.

Procedure and observations. Cut across the branch at right angles and at intervals of about six inches. If the cut is not smooth enough so that you can easily count the annual rings, smooth it on the sandpaper. Count the rings on the upper end of each section. Draw below as many circles to represent cross sections of the stem as you made cuts. In each write the number of rings.

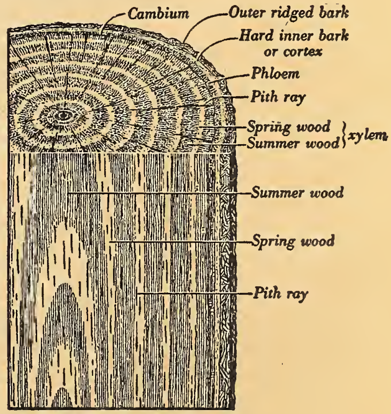


Fig. 4

GUIDE QUESTIONS FOR STUDY. STEMS

[Text pages 100–104]

1. List the characteristics of each type of bud opposite its name.

BUD	CHARACTERISTICS
Leaf bud	---
Flower bud . . .	---
Mixed bud . . .	---
Adventitious . . .	---
Axillary, or lateral	---
Terminal	---

2. Explain how an annual ring is formed.

3. List the functions of stems.

4. List economic uses of stems.

*EXPERIMENT 27. THE STRUCTURE OF A ROOT

Problem. What is the structure of a fleshy root?

Materials. Carrot or parsnip; knife.

Procedure and observations. Cut a lengthwise section through the root. Note the difference in color between the inner cylinder, called the central cylinder, and the outer part, called the cortex.

Note in the central cylinder the whitish threads, which are fibrovascular bundles. Find a place where a secondary root branches from the main root. Does it connect with the cortex or with the central cylinder? Complete Fig. 5 to indicate the correct answer.

Cut a cross section of the root. In Fig. 6 draw and label the epidermis, cortex, and central cylinder.

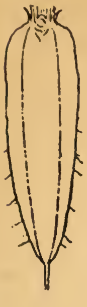


Fig. 5

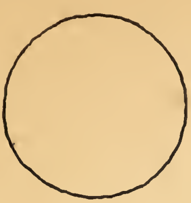


Fig. 6

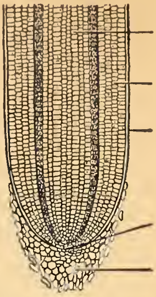


Fig. 7

EXPERIMENT 28. THE STRUCTURE OF A YOUNG ROOT

Problem. What is the structure of a young root?

Materials. Small rootlets on germinating pea seeds or on seeds of corn, radish, onion, or mustard; or fine roots on slips of wandering Jew or geranium growing in water; microscope; slide and cover glass.

Procedure and observations. Remove one of the small roots from the seedling or slip, and mount it in water. Examine with the low-power objective. The dark central region is the central cylinder, made up largely of fibrovascular bundles. On either side of the central cylinder is the cortex. On the outside of the root there is a single layer of cells, the epidermis. At the tip of the root note the root cap. Just behind the root cap is the growing point (meristem).

Conclusion. After you have identified the structures described above, label them on Fig. 7.

*EXPERIMENT 29. ROOT HAIRS

Problem. Where are root hairs found? What is their structure?

Materials. Germinating radish or mustard seeds; microscope; slide.

Procedure and observations. Note the fuzzy, hair-like structures on the root. Where are they most abundant—(1) on the root tip? (2) near the seed? (3) about halfway between the seed and the root tip? (4) somewhat nearer the root tip than the seed? (5) at no portion more than at any other? Underline your answer.

Can you see an advantage in this location of the root hairs?

Place a piece of the root bearing a few root hairs on a slide, and examine it with first the low-power and then the high-power objective of the microscope.

Are the walls thick or thin? ____________ Of what advantage is this adaptation?

EXPERIMENT 30 (OPTIONAL). RATE OF ROOT GROWTH

Problem. What part of a root grows most rapidly?

Materials. Seeds of any kind; moist paper; a dish with a cover; red ink; ruler.

Procedure and observations. Line the dish with paper, and moisten it well. Place the seeds on the paper, and cover them with another layer of wet paper. Put a cover on the dish to prevent evaporation of water. When the roots are about an inch long, place dots of red ink on them at $\frac{1}{8}$-inch intervals. After two days measure the distances between the dots. Show by a sketch where the root has grown most. Measure again on the fifth day, and make a sketch to indicate the distance between the dots.

Conclusion. Answer with a complete sentence the question asked in the problem.

EXPERIMENT 31. UNDERGROUND STEMS AND ROOTS

Problem. What are the differences between underground stems and roots?

Materials. Fleshy roots, such as carrots, beets, or parsnips; white potatoes; onions; knife.

Procedure and observations. Examine a potato. Describe any structures which you find similar to those on a tree stem.

Do you find any small roots? ------------ If so, where?

Cut an onion in two from top to bottom. Examine the layers, noting the veins in them. The veins indicate that the layers are probably modified forms of what structures? ---------------

--------------- What is the small cone-shaped structure to which the layers are fastened?

What evidence of roots do you find?

Examine a carrot. Can you find either buds or leaves on it? ------- If so, where?

Can you find any small roots? ------- If so, where?

Conclusions. The potato and the onion are underground stems; the carrot is a root. In not more than three sentences explain how you can distinguish underground stems from roots.

GUIDE QUESTIONS FOR STUDY. ROOTS

[Text pages 104–115]

1. Compare fibrous roots (for example, those of grass) with fleshy roots (like carrots or radishes). (See "How to Study," p. x of *Everyday Biology*.)

SIMILARITIES	DIFFERENCES

2. Give two or three examples of plants which have each of these types of roots:

(1) *Fleshy roots, for food storage*

(2) *Taproots*

(3) *Fibrous roots*

(4) *Holdfast roots*

(5) *Parasitic roots*

3. List the structures of a root, and opposite each write its function.

STRUCTURE	FUNCTION

4. What is the function of the root cap?

5. List the plant structures in which food is stored, and give an example of each.

PLANT STRUCTURE	EXAMPLE

6. If one wished to grow plants on a slope to prevent the erosion of the soil, what type of root system would be most desirable?

7. What type of root system is illustrated by each of the seedlings in the first figure on page 106 of *Everyday Biology*?

8. How do the plant fruits which animals eat serve as an aid to the survival of the plant?

9. From your study of Unit II, supplemented with other information which you may possess, write under each plant structure in the table below as many uses as possible which man makes of these structures or products from them.

ROOTS	STEMS	LEAVES

Self-test on Biological Terms. Be sure you can define these words. Check your definitions with those in the Glossary of your textbook.

bud
cambium
cortex
dicot
epidermis
phloem
pith
monocot
root hair
xylem

NAME___________________________________ DATE________________

GUIDE QUESTIONS FOR STUDY. CLASSIFICATION

[Text pages 118–126]

1. State in one sentence why a scheme of classification is needed.

2. Beginning with the largest group, name in order the smaller groups and give a brief definition of each.

Kingdom	*One of the two great divisions of living things*

EXPERIMENT 32. ALGAE (PLEUROCOCCUS)

Problem. What is the appearance under the microscope of a one-celled alga (*Pleurococcus*)?

Materials. Some of the green material found on the north side of a tree or of a post; microscope; slide; cover glass.

Procedure and observations. Place a drop of water on a slide, and into it scrape some of the green material. Examine it under low power and then under high power. Each of the small rounded green cells is a single plant (*Pleurococcus*).

Are some of the cells grouped in colonies of two or more? __________________________

Draw one or two single specimens of *Pleurococcus*.

EXPERIMENT 33. ALGAE (FILAMENTOUS ALGAE)

Problem. What is the appearance under the microscope of the thread-like algae?
Materials. Pond scum; microscope; slide and cover glass.

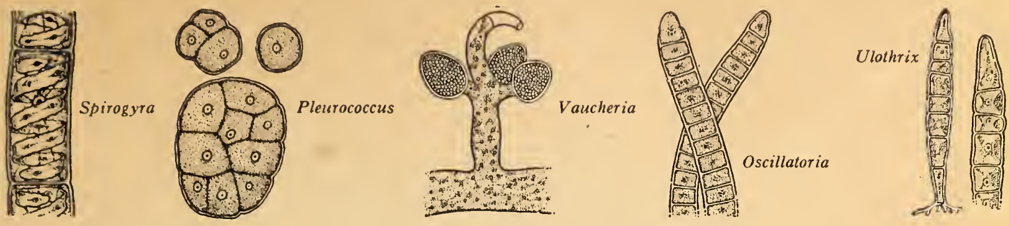


Fig. 1

Procedure and observations. Mount a few threads (filaments) of the algae. Note the long cells placed end to end to make up the filament. Do any of the filaments branch? ------------ Note the shape and arrangement of the chloroplasts in different filaments. Compare the algae you observe with those in the figure. Place a check beside each that you can identify in your slides. Sketch your specimen if it is different from any of the algae shown in Fig. 1.

EXPERIMENT 34 (OPTIONAL). DIATOMS

Problem. What are the characteristics of diatoms?
Materials. Water and ooze from a stagnant pond or pool; microscope; slides and cover glasses.
Procedure and observations. Place a drop of the water on a slide, and examine it with the microscope. Can you find any of the kinds of algae shown in the figure on page 130 of the textbook? ------------ Do you find other kinds? -------------------------------- Make sketches of some of the most interesting kinds you find.

EXPERIMENT 35 (OPTIONAL). LICHENS

Problem. Where may lichens be found? What is the structure of a lichen?

Materials. Lichens[1]; microscope; slide and cover glasses.

Procedure and observations. Place a small piece of one of the lichens in a drop of water on a slide. Cover the material with a cover glass, and press it down firmly. Examine it under the low-power objective. Note the small round green cells. What kind of plant do they most resemble?

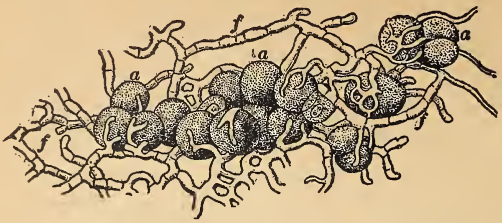


Fig. 2. A piece of lichen (after Bonnier, magnified 500 diameters)

Note, too, threads or masses of white material. What kind of plants lack chlorophyll?

------------------------------ A lichen is really made up of these two plants living together

Such a relationship is an example of -------------------- (see pages 135–137 of the text).

What advantage does each plant derive from the partnership?

---

[1] Look on the bark of trees for patches of gray or gray-green material. Some of these patches will be merely rough and uneven masses; others will be flat with curled edges standing up. Both are kinds of lichens. You may find other lichens growing on rocks or on sandy soil. Some of these are many-branched forms, perhaps four inches tall (usually species of *Cladonia*).

NAME ________________________ DATE ________________

*EXPERIMENT 36. BACTERIA

Problem. Where may bacteria be found?

Materials. Two hundred cubic centimeters of water; 3 grams of agar-agar; 1 gram of beef extract (1 gram of salt and 1 gram of peptone may be added); large beaker or pan; funnel; flask; cotton; test tubes; Petri dishes; Bunsen burner; gummed paper or adhesive tape.

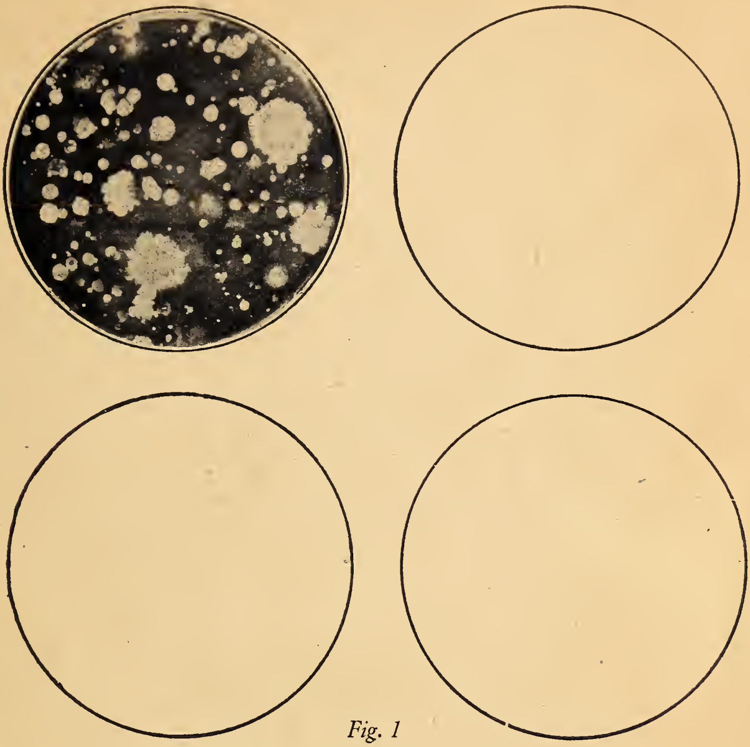


Fig. 1

Procedure and observations. Put the water, agar-agar, and beef extract into a large beaker or a pan. Heat the mixture until all the agar-agar is dissolved. Strain through cotton into the flask. Heat again, and, if the mixture (culture medium) is not clear, strain again. In the meantime sterilize the test tubes and the Petri dishes by boiling them for ten minutes. Then pour the sterile culture medium into the test tubes and Petri dishes; put the covers on the dishes, and plug the tubes with cotton; let them stand until the medium is cool and firm.

Seal one dish with gummed paper (or adhesive tape), and set it aside as a control. Expose other dishes or tubes (1) to the air of the classroom for three minutes; (2) to air out of doors; (3) to dirt from the floor or table; (4) to contact with a dirty finger; (5) to a drop of water; (6) to somebody's breath; (7) to somebody's coughing or sneezing; (8) to a drop of milk; (9) to contact with bits of food; or (10) to other things on which or in which bacteria might be found. Cover the dishes or the tubes and set them in a warm dark place for several days. Examine them daily. How soon do the first spots, or colonies of bacteria, appear?

Do they appear in all the dishes? ________________

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Choose one of your dishes which has been exposed to bacteria, and sketch in the circles in the figure a record of it for three days, showing (1) whether colonies of bacteria become more numerous or less numerous; (2) whether or not colonies increase in size; and (3) whether there seem to be colonies of more than one kind of bacteria.

Conclusions. What does your experiment show as to where bacteria may be found?

Exercise on Scientific Method. What were the controls, and why were they necessary?

EXPERIMENT 37 (OPTIONAL). STUDYING BACTERIA

Materials. Your bacteria cultures; compound microscope; cover glass and slides.

Procedure and observations. (It is difficult to observe bacteria; you may not be successful in doing so.) Place a drop of water on the slide, add some of the material from one of the bacterial colonies, observe it through the low-power and then the high-power objective. What shape are the bacteria (p. 132 of the textbook) which you are observing?

In the space below draw sketches representing the types of bacteria which you observe.

Special Report. Prepare a ten-minute talk to be given in class on either "The History of the Study of Bacteria" or "Useful Bacteria." Write your notes for the talk here. Use an extra sheet of paper if necessary.

*EXPERIMENT 38. MOLDS

Problem. What are the parts of a mold plant?

Materials. Test tubes; cotton; clear, colorless fruit juice.

Procedure and observations. Fill each of several test tubes half full of clear fruit juice diluted half with water. If the fruit juice is not clear, filter it through fine cheesecloth or filter paper. Inoculate the fruit juice with mold by transferring some mold to it, if you have some; if not, by sprinkling into it a little dust from the window sills or floor. Plug the tubes with cotton, and keep them in a dark place. Examine them from day to day. When the mold plants are large enough so that their structures may be clearly seen, compare what you observe with the figure on page 134 of *Everyday Biology*. In the space below make a sketch of one of the mold plants, labeling the mycelia, or thread-like root structures; the hyphae, or stalks; and the sporangia, or spore cases.

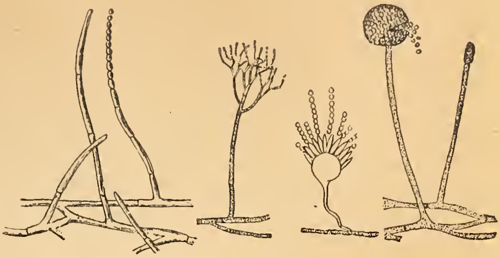


Fig. 2. Milk mold, blue mold (Penicillium glaucum), *black mold* (Aspergillus niger), *and white mold* (Mucor mucedo)

Remove a small piece of mold, and make a slide of it. What structures can you distinguish under the microscope?

Can you find spores? ------------------ If so, add them to your sketch.

EXPERIMENT 39 (OPTIONAL). KINDS OF MOLDS

Problem. How many different kinds of molds can I grow?

Materials. Piece of bread; two saucers; magnifying glass or microscope.

Procedure and observations. Moisten the piece of bread, put it in a saucer, and sprinkle it with dust from a number of different parts of the room or of several rooms. If you already have some mold plants, put a bit of each plant on the bread. Cover the saucer in which you have put the bread with the other saucer, and put both saucers aside in a warm place for several days. Examine your culture. Describe here in words or with sketches the different kinds of mold you have.

GUIDE QUESTIONS FOR STUDY. ALGAE

[Text pages 128–131]

1. To what phylum do algae belong? ____________________

2. What other plants belong in the same phylum?

3. The phylum of simple plants is made up of the green plants called ____________________ and the plants without chlorophyll called ____________________

4. The algae are independent plants. What does this statement mean?

5. The fungi are dependent plants. What does this statement mean?

6. Should you expect to find algae in arid regions? _______ Explain.

7. In what ways are algae important to man?

8. Examples of fungi are the following:

GUIDE QUESTIONS FOR STUDY. BACTERIA

[Text pages 131–134]

1. How are bacteria of decay useful to man and other organisms?

2. What are aerobic and anaerobic bacteria? (You may need to consult an unabridged dictionary or a textbook in botany or physiology.)

3. Bacteria are successful plants. Explain.

4. Why are the upper layers of soil "rich in bacterial life"?

5. The three conditions most favorable to bacterial growth are (1) ____________________ ____________________, (2) ____, and (3) ____.

6. Does division of labor take place in bacteria? ____________________ Justify your answer.

GUIDE QUESTIONS FOR STUDY. FUNGI

[Text pages 134–137]

1. What do you think are the functions of the mycelia, the hyphae, and the spores of mold plants?

2. Is the mold you have been studying a parasite or a saprophyte? ____________________________ Explain.

3. State one or more ways in which yeasts are like molds, and one or more ways in which they are unlike molds.

4. What are the functions of the mycelia and the cap of a mushroom?

5. List ways in which fungi are useful to man.

GUIDE QUESTIONS FOR STUDY. MOSSES AND FERNS

[Text pages 138–141]

1. What groups of plants constitute the bryophytes?

2. Are mosses and liverworts parasites, saprophytes, or neither? ------------------ Justify your answer.

3. State two reasons why, because of their structure, mosses cannot be tall plants.

4. List three or more reasons why mosses are important.

5. What three groups of plants constitute the pteridophytes?

6. What characteristics of ferns make them higher plants than the thallophytes and the bryophytes?

*EXPERIMENT 40. STRUCTURE OF A SEED

Problem. What is the structure of a typical seed?

Materials. Lima or kidney beans, soaked overnight; corn grains that have been soaked overnight; knife; iodine solution; hand lens.

Procedure and observations. 1. *Dicot seed.* On one side of the bean find the hilum, or scar, where the seed was attached to the pod. Near one end of this scar is a tiny opening (the micropyle). It permitted the entrance of the pollen tube when the egg which produced the seed was fertilized; it may also serve to admit water. Label this view of bean in Fig. 3, *A*.

Remove the seed coat (testa). Note the two halves, or cotyledons, into which the bean separates readily. Break them apart carefully. Near one end you will find two tiny leaves, the plumule; near by is a rod-like structure, the hypocotyl. Label this view of bean in Fig. 3, *B*.

2. *Monocot seed.* As you examine a corn grain, note the light-colored region on one side. This is the embryo. Cut the grain in two lengthwise at right angles to the embryo. Stain the cut surface lightly with iodine. The part which stains most deeply is the stored food (endosperm). The other part of the grain is embryo. It is made up of plumule, hypocotyl, and cotyledon. Label these in Fig. 4, *A* and *B*.

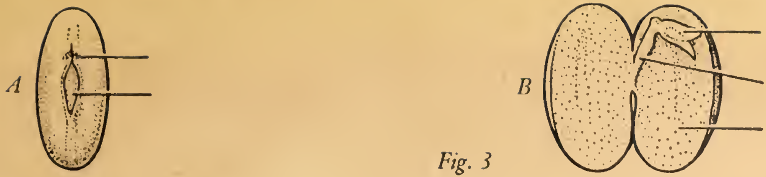


Fig. 3

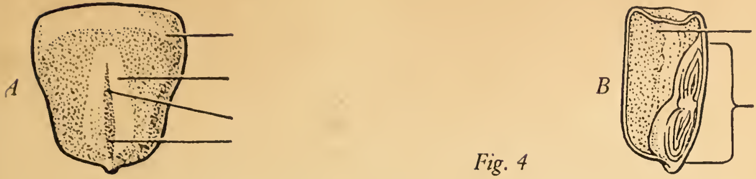


Fig. 4

*EXPERIMENT 41. GERMINATION OF SEEDS

Problem. How does a seed grow to produce a plant?

Materials. Soaked bean seeds, corn grains, radish, pea or other seeds; box of dirt or sawdust.

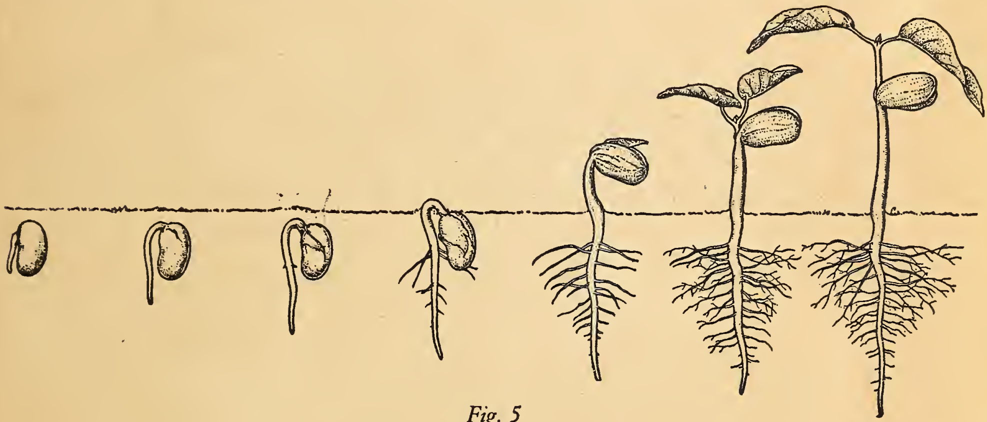


Fig. 5

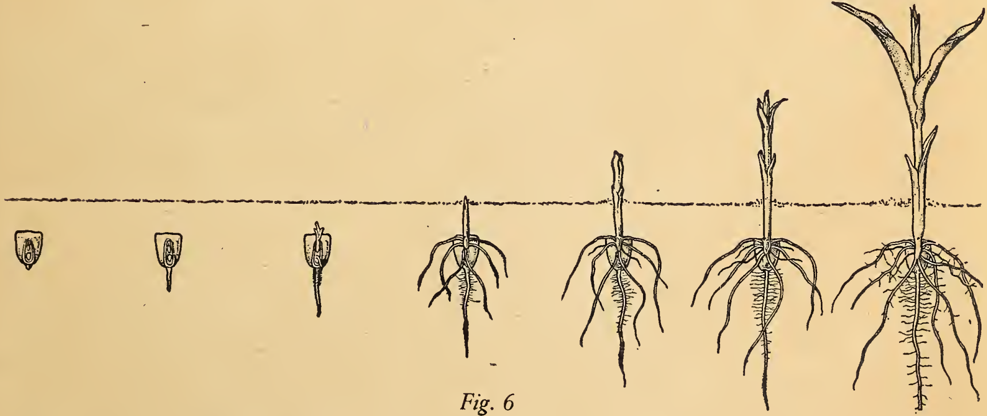


Fig. 6

Procedure and observations. Plant six or eight seeds of each kind in the dirt or the sawdust. Keep the soil or the sawdust moist, but not too wet. Dig up and examine one seed of each kind every day. Examine the seed structures carefully with the hand lens. Record the answers to the questions asked in the table on the following page.

	Bean	Corn	
Number of days before seed coat breaks			
Part of embryo which first breaks through seed coat			
Part of embryo which first appears above ground .			
Functions of the cotyledon			
Structures which develop from the plumule			
Structures which develop from the hypocotyl . . .			

What becomes of the cotyledons of the monocot seeds?

Of the dicot seeds?

Label cotyledons, plumule, and hypocotyl in Figs. 5 and 6 on page 57.

GUIDE QUESTIONS FOR STUDY. SPERMATOPHYTES

[Text pages 142–147]

1. Give the distinguishing characteristics of each of the two great groups of Spermatophyta.

2. Supply the facts needed to complete the table.

	DISTINGUISHING CHARACTERISTICS			
	Seeds	Stems	Leaves	Flowers
Monocots				
Dicots				

Self-test on Biological Terms. Be sure you can define these words. Check your definitions with those in the Glossary of your textbook.

algae fungi bacteria spore fermentation

PROJECT 6. TO IDENTIFY CONE-BEARING TREES

Procedure. Using the key on page 126 of *Everyday Biology*, identify the cone-bearing trees (conifers) of your locality. From as many as possible of these collect some cones that have not yet opened. When they are dry, the scales will open and expose the seeds. Make a record of the different kinds you identify, stating where each grows.

PROJECT 7. TO CLASSIFY SEEDS AS MONOCOTS OR DICOTS

Procedure. Soak various kinds of seeds, such as peanut, sunflower, radish, pea, oats, and wheat. Examine them as you did the beans and corn. Classify the seeds as monocotyledons or dicotyledons. Make a record of those that belong in each group.

PROJECT 8. TO STUDY THE GROWTH OF A YOUNG PINE

Procedure. Plant some of the seeds from a pine cone. Watch the plant closely as it comes through the ground. How many cotyledons are there? Explain why the cone-bearing trees might be called polycotyledons. (See dictionary.)

PROJECT 9. TO IDENTIFY MONOCOTS AND DICOTS

Procedure. Find twenty or more monocots and twenty or more dicots which have not been mentioned in Chapter IX of *Everyday Biology*. Use the summary given on page 145 of *Everyday Biology* to distinguish monocots and dicots. Keep a record of your plants, naming each if you can find its name. State for each plant the characteristics which led you to classify it as either a monocot or a dicot.

PROJECT 10. TO IDENTIFY TWENTY OR MORE COMMON WILD FLOWERS

Procedure. Use a flower guide to learn to recognize members of our commonest families of flowers. Keep a record of those you identify.

NAME______________________________ DATE______________

EXPERIMENT 42. PROTOZOA

Problem. What are some common Protozoa?

Materials. Some hay or grass; jar; pond water and weeds, if available; compound microscope; slides and cover glasses.

Procedure and observations. Cut some hay or grass into pieces and put it into a jar of water. In another jar put some pond weeds and water. Let both jars stand for a week. Then put a drop of the water from the first jar on a slide, and examine it under the low-power objective of the microscope. Observe any animals moving about in the water.

In the same way examine a drop of water from the second jar. Make other slides from each jar.

How many different kinds of animals do there seem to be in your cultures? ______________

Do the Protozoa you are observing seem to have a head end; that is, do they usually move with a definite end forward? ______________ Do many of them collect in one spot? ______________

Can you identify in your cultures any of the common Protozoa shown in the figure? If so, put a check beside each protozoan which you recognize. Sketch any others you see.

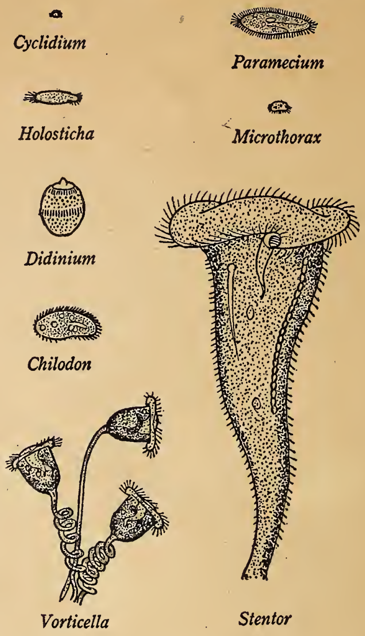


Fig. 1. Common Protozoa. They are here drawn to scale to indicate their relative size

*EXPERIMENT 43. CHARACTERISTICS OF *PARAMECIUM*

Problem. What are the characteristics of *Paramecium*?

Materials. Culture of *Paramecium*; slides and cover glasses; compound microscope; cotton.

Procedure and observations. Put a drop of water containing paramecia on a slide; add two or three threads of absorbent cotton to keep the animals from swimming out of range too readily and to support the cover glass so that they will not be crushed. Examine the slide under low power. Watch the animals as they encounter objects in their paths. Do their bodies bend at all as they go under or over objects? _________

Describe how they move about.

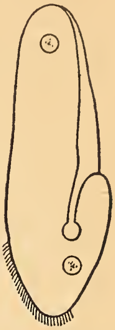


Fig. 2

Hold your hand in such a position as to cut off some light from the slide. You should now be able to see the hair-like cilia which aid in swimming. Along one side of the body note the funnel-shaped groove. What seems to be its purpose?

Find some of the denser masses of material within the protoplasm. These are food vacuoles. Look closely near each end of the animal for a clear space that changes in size. These are the contractile vacuoles, used in discharging wastes.

Add to the drawing any structures of the paramecium which you have observed but which are not included in the drawing. You will study *Paramecium* many times in *Everyday Biology*. Whenever you learn the names of any of these structures and their functions, add them to this drawing.

EXPERIMENT 44. CHARACTERISTICS OF *AMOEBA*

Problem. What are the characteristics of *Amoeba*?

Materials. Culture of *Amoeba*; slides; compound microscope.

Procedure and observations. Place an amoeba on a slide and examine it with the low-power objective of the microscope. Does it have a definite shape, or does the shape change as it moves?

Make small sketches showing the amoeba at intervals of one minute for five minutes to show how it moves.

Watch the animal closely as it encounters a particle of food. How does it eat the food?

Turn to the high-power objective. Note the many small grains of matter which make up the body and which continuously roll over one another. You are observing protoplasm, which usually has a granular nature.

Does the amoeba appear to have a cell wall?

GUIDE QUESTIONS FOR STUDY. PROTOZOA

[Text pages 149–154]

1. Where are Protozoa found?

2. How did the Protozoa get into the culture you made?

3. How do Protozoa manage to survive winter or periods of drought?

4. Of what importance are Protozoa?

EXPERIMENT 45. SPONGE

Problem. What is the general structure of a sponge?

Materials. Commercial bath sponge.

Procedure and observations. Secure at a drugstore or other store a sponge that has not been trimmed closely. Note that there are several cone-shaped projections, each with a central cavity. Each of these is a separate sponge. Find smaller sponges which bud from a larger one. This method of reproduction produces the large sponge mass.

Examine the fibers which make up the skeleton, and note the spaces between the fibers, which in the live sponge were filled with protoplasm.

EXPERIMENT 46. *HYDRA*

Problem. What is the general structure of *Hydra*?

Materials. Live fresh-water hydras; medicine-dropper; slide; hand lens; compound microscope; prepared slide showing longitudinal section, if possible.

Procedure and observations. Fill the medicine-dropper with water. Then, holding the end of it near the hydra, force a jet of water against the animal to detach it from the jar. Then gently pick up the hydra with the medicine-dropper. Place it in a drop of water on a slide. Do not use a cover glass. Examine the hydra with the hand lens or the low-power objective of the microscope. Note the general shape of the animal.

How many arm-like organs, or tentacles, do you find around the mouth? _______________

What seems to be their use?

Can the animal change its size or its shape? ____________________

What observations make you certain of your answer?

In the space below sketch the hydra to show its general structures. Make other sketches to show any interesting behavior of the hydra that you observed, such as moving about and feeding.

If a prepared slide of *Hydra* is available, examine it with low power.

How many layers of cells are there? ____________________

EXPERIMENT 47. STARFISH

Problem. What are some of the characteristics of the starfish?

Material. Live, dried, or preserved starfish.

Procedure and observations. How many arms, or rays, does your specimen have? __________

Are any of the arms smaller than the others? _______________

If so, how do you account for this fact?

With what is the body covered?

On the under (ventral) surface find the tube feet. On the upper (dorsal) surface locate the small sieve-like plate (madrepore), which admits water for the tube feet.

GUIDE QUESTIONS FOR STUDY. SPONGE

[Text pages 154–158]

1. To what phylum does the sponge belong? ______________________________________
2. List the distinguishing characteristics of the animals in this phylum.

3. The sponge has a complete metamorphosis in its life history. Explain.

4. How does the sponge illustrate true division of labor?

GUIDE QUESTIONS FOR STUDY. *HYDRA*

[Text pages 158–163]

1. To what phylum does *Hydra* belong? ______________________________________
2. What are the distinguishing characteristics of *Hydra* and its relatives?

3. How does *Hydra* illustrate division of labor?

4. Are hydras parasites, saprophytes, or neither? __________________ Justify your answer.

5. Jellyfish measuring many feet in circumference have been found. They could not attain such great size if they did not live in the water. Can you explain why?

6. What is meant by "alternation of generations" in the jellyfish?

Special Report. Prepare a ten-minute report on either the sponge industry or corals, to be delivered before your classmates. In the space below jot down your notes in brief form, following the plan for a discussion described in "How to Study," p. ix of your textbook.

GUIDE QUESTIONS FOR STUDY. SIMPLE ANIMALS

[Text pages 164–173]

1. Which of the six phyla discussed thus far contain parasitic animals?

Complete the following chart, listing the most important parasites found in these phyla, and their hosts:

PHYLUM	PARASITE	HOSTS
(1) *Platyhelminthes*	*Tapeworm*	*Man, dog, fish, pig*
(2)		
(3)		
(4)		
(5)		
(6)		

2. Of the parasites in these phyla, which can go (*a*) from one animal to another of the same species and (*b*) which require alternate hosts?

3. List after each heading two or more animals from these phyla which fit the description in the heading.

(1) *Those that crawl*

(2) *Those that swim*

(3) *Those that are attached to a host*

(4) *Those that are attached to a nonliving object*

4. Make a drawing or a diagram, similar to the figure on page 167 of *Everyday Biology*, illustrating the life history of the tapeworm or the hookworm.

2. *Internal structure.* Place a dead or preserved worm in a wax-filled dissecting pan or on a board. With sharp-pointed scissors cut through the body wall along the back of the animal, beginning about halfway back and continuing forward to the head. Pin the body wall back by thrusting pins through it into the wax or board. Note the fine partitions which hold the body wall in place. What is their position in relation to the segments?

The space between the body wall and the internal organs is the body cavity. Trace the digestive system, which consists of mouth, pharynx, esophagus, crop, gizzard, and intestine, in this order. Above the digestive tract find a blood vessel which extends the length of the worm. There is a similar blood vessel below the digestive tract as well. Many smaller vessels connect these two. Near the head end look for five pairs of enlarged connecting vessels, the hearts. Remove a portion of the intestine, and look on the floor of the body cavity for the nerve cord. This nerve cord is enlarged in each segment to form a ganglion. The brain is located above the pharynx.

Use Fig. 4 to help you to identify as many of the structures as you can. Add labels to the diagram to indicate the structures that you are able to identify.

3. *Circulation.* See Experiment 75, p. 124 of this workbook.[1]

Exercise on Scientific Method (Making Inferences)

1. Did you find any structure of the earthworm which you thought might serve as lungs?

_______ If so, where?

2. How do you think the earthworm "breathes"?

3. Why must the earthworm live in a moist habitat?

GUIDE QUESTIONS FOR STUDY. THE ANNELIDS

[Text pages 173–176]

1. To what phylum does the earthworm belong? ______________________________________

2. Name several other members of this phylum.

3. What are the distinguishing characteristics of the annelids?

(1)

(2)

(3)

(4)

---

[1] *To the Teacher.* You may wish at this time to perform Experiment 75, p. 124, on the "Circulation in the Earthworm," and to include it as part 3 of this experiment.

4. How does the earthworm aid in soil improvement?

5. What is meant by saying that the leech is a temporary parasite?

GUIDE QUESTIONS FOR STUDY. THE MOLLUSKS

[Text pages 176–183]

---

1. List some common mollusks which live on land.

Some which live in fresh water.

Some which live in the ocean.

2. What are the distinguishing characteristics of the mollusks?

(1)

(2)

(3)

3. Name one or more mollusks which are univalves, that is, animals having a single shell.

Name one or more bivalves, that is, mollusks with two shells hinged together.

One or more without external shells.

4. Does the mussel undergo a complete or an incomplete metamorphosis? (See "metamorphosis" in the Glossary of your textbook; also the accompanying reference.)

Justify your answer.

5. List mollusks of economic importance and give commercial uses of each.

Self-test on Biological Terms. Be sure you can define these words. Check your definitions with those in the Glossary of your textbook.

anterior
aquatic
cilia
dorsal
exoskeleton
invertebrate
metamorphosis
parasite
primitive
Protozoa
segment
ventral

Special Reports. 1. The oyster industries of the Gulf of Mexico, the Chesapeake Bay region, and the Pacific coast. (Consult bulletins of the United States Bureau of Fisheries.)

2. Pearl-fishing in the Mississippi River basin.

3. The clam industries of the Atlantic and the Pacific coasts.

4. The source of cuttlebone, which is often placed in bird cages.

Jot down your notes in the space below.

NAME ____ DATE _________________

*EXPERIMENT 49. THE CRAYFISH[1]

Problem. What are some of the most important characteristics of the crayfish?

Materials. Live crayfish; pan or tank of water; preserved crayfish; dissecting instruments.

Procedure and observations. 1. *Locomotion.* How does the crayfish move about when on land?

Has it any legs which it does not use? _______ Can it move sideways? _______ Backward?

_______ Do you find any evidence that it is using its eyes to see where to go?

For what does it appear to use the antennae?

Put the crayfish into a vessel of water in which it will have room to swim. How does it move now?

What part of its body does it use to produce this movement? ________________________ Which of its various methods of locomotion would be more useful in finding food?

In escaping from enemies?

Which method is most rapid?

2. *General characteristics.* Note that the body of the crayfish is divided into two distinct regions: the head-thorax and the abdomen (which looks like a tail). Is the head movable? _______ Which region of the body is most distinctly segmented? ____________________________ How many legs are there? _______ Which pairs of legs have claws? ________________________________

What is the use of each pair, as far as you can observe?

---

[1] You will probably need four forty-five-minute periods in order to complete this entire experiment on the crayfish.

How many eyes has the crayfish? _______ These are compound eyes. You will find one long pair of antennae and one shorter pair. The latter, the antennules, are two-parted, appearing at first to be two pairs. Are the antennae segmented? _______ Find the jointed stalks which attach the antennae to the body. Of what advantage are these joints?

Where is the mouth of the animal?

Hold a piece of paper or your pencil point against the crayfish's mouth. Describe the mouth parts and their action.

Summarize this section by giving five characteristics of the crayfish.

(1)

(2)

(3)

(4)

(5)

3. *Protection.* Hold the crayfish up in the air. How does it try to get away from you?

What is the color of the living animal? __________ In what way is its color a protection?

Examine one of the legs of a preserved crayfish. How many jointed sections do you find? _______ What is the advantage of having so many joints?

Squeeze the leg firmly between the fingers. Does it crush easily? _______

Remove the hard covering to expose the muscles of the large claw. Where do you find that the muscles are attached?

4. *Breathing.* Hold the live crayfish, ventral side up, in a pan of water. (The water should just cover the animal.) Put a drop of ink near the rear legs. What happens to it?

Where does the ink reappear?

How do you infer that it got there?

Does it come from the mouth? _______ How can you tell?

Use a preserved specimen for the next observations. With scissors cut off the shell (carapace) on one side of the body. The region exposed is the gill chamber. Describe the gills.

Place the point of the scissors between the legs of the middle pair, and cut off one of the legs close to the body. What relation do you discover between the legs and the gills?

Put a gill in water. What is the advantage derived from having so many fine divisions?

In the space below make a sketch of a leg with the attached gill.

5. *Body regions and appendages.* (1) *The head-thorax* (*cephalothorax*). Is the head movable? _______ Can the live crayfish move its eyes? _______ Gently touch one of the eyes with your pencil. It will not hurt the crayfish. Why?

What happens?

Of what advantage is the jointed eye-stalk?

Complete Fig. 1, showing the head region from above. Add antennae, antennules, and eyes.

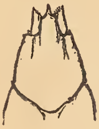


Fig. 1. Head region of crayfish (dorsal view)

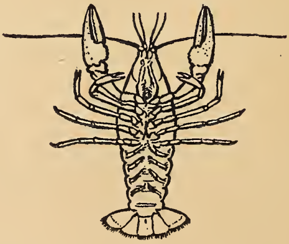


Fig. 2. Ventral view of crayfish

Remove a piece from the surface of one of the eyes and examine it under the low-power of the microscope. Sketch what you observe.

Examine the mouth parts. Get help from your teacher to remove them, and compare them with the figure on page 191 of the textbook. Sketch them and properly label your drawings, or glue the mouth parts to a piece of cardboard in the proper order.

Look over the four sections you have just completed, and list four or five characteristics of the grasshopper.

(1)

(2)

(3)

(4)

(5)

Examine other insects to see whether all possess the characteristics you have listed. Check each characteristic which you think is found in all typical insects.

EXPERIMENT 52 (OPTIONAL). CLASSIFYING ORDERS OF INSECTS

Problem. To what orders do common insects belong?

Materials. Specimens of various kinds of insects.

Procedure and observations. Use this key in classifying your specimens. Put with each specimen a paper upon which you write the order to which the insect belongs.

KEY

	Order
With two wings only	*Diptera*
With four wings	
Outer pair of wings hard and shell-like	*Coleoptera*
Outer wings with the front half hard and the rear half membranous	*Hemiptera*
Wings much alike	
Both pairs of wings colored; covered with scales	*Lepidoptera*
Wings thin and transparent	
Outer wings folded over inner fan-like wings; held close along the body when at rest	*Orthoptera*
Wings held at right angles to the body	
Mouth parts for sucking and chewing	*Hymenoptera*
Mouth parts for chewing	*Odonata*

List here the insects you have classified as belonging in the various orders.

Diptera

Coleoptera

Hemiptera

Lepidoptera

Orthoptera

Hymenoptera

Odonata

GUIDE QUESTIONS FOR STUDY. ARTHROPODS

[Text pages 184–203]

1. List the distinguishing characteristics of arthropods.

(1)

(2)

(3)

(4)

2. Name the four classes of arthropods, and give an example of each.

(1)

(2)

(3)

(4)

3. Compare a crustacean with an insect (see "How to Study," p. x of your textbook).

SIMILARITIES	DIFFERENCES

4. What are the characteristics of an insect which distinguish it from all other arthropods?

(1)

(2)

(3)

5. Give three examples of protective coloration or protective resemblance in arthropods.

6. What are the advantages and the disadvantages of an exoskeleton?

7. Contrast complete metamorphosis with incomplete metamorphosis.

8. List eight reasons why insects are successful animals.

(1)

(2)

(3)

(4)

(5)

(6)

(7)

(8)

Self-test on Biological Terms. Be sure you can define these words. Check your definitions with those in the Glossary of your textbook.

abdomen
antenna
appendage
arthropod
exoskeleton
larva
posterior
protective adaptation
segment
thorax
ventral

EXPERIMENT 53 (OPTIONAL). LIFE HISTORY OF AN INSECT (THE MOSQUITO)

Problem. What are the distinct stages in the life history of the mosquito?

Materials. Mosquito eggs[1]; jar; mosquito netting.

Procedure and observations. Put the eggs in a jar of water, and put some mosquito netting over the top of the jar to prevent the escape of the adult mosquitoes when they develop. Keep a record of the number of days which the young mosquitoes spend in each stage.

1. Egg -------------- days 2. Larva ------------- days 3. Pupa ------------- days

---

[1] This experiment will need to be performed in the early fall or in the spring because mosquitoes lay their eggs from April to October. The eggs, which look like bits of soot, are laid on the surface of still water. Cans of water will furnish breeding places, if you cannot find eggs in stagnant pools. You are most likely to secure the raft-like egg masses of the common mosquito (*Culex*), but you may find some of the malarial mosquito (*Anopheles*).

Observe how the larvae move through the water when the dish is jarred. Note the breathing tube which the larva, or wiggler, pushes above the surface of the water. Dip out a few of the larvae into another vessel. Pour a little kerosene on top of the water, and observe results carefully. Describe what you observe.

Can you explain what happened?

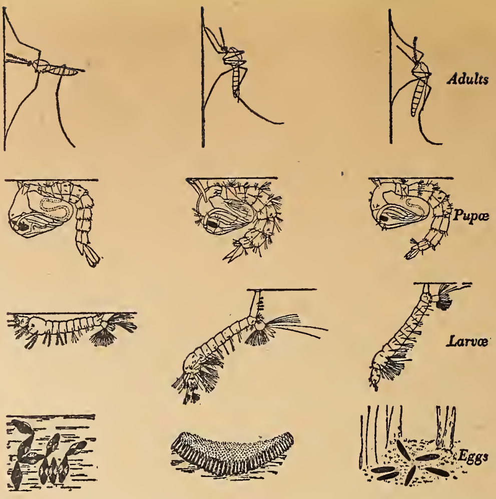


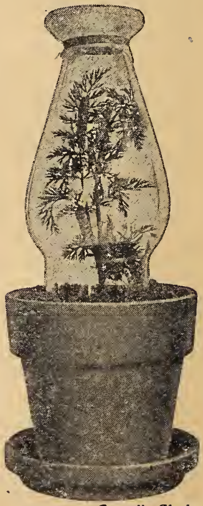
Fig. 5. Life histories of mosquitoes. Left, malarial mosquito (Anopheles)*; center, common mosquito* (Culex)*; right, yellow-fever mosquito* (Aëdes)

Repeat the last experiment, using some of the pupae instead of the larvae. Are the results the same or different? --

PROJECT 11. TO STUDY THE LIFE HISTORIES OF OTHER INSECTS[1]

Procedure. In the spring of the year insect eggs can often be found upon the under-sides of leaves, under scales of bark, or in holes in a tree trunk. Larvae will be found on the leaves or twigs. Place each kind of eggs or larvae by itself in a bottle or small box, to carry it safely home or to the laboratory. Make a note of the kind of tree upon which each kind of eggs or larvae is found, in order to provide the larvae with the kind of food they must have. Cover the mouths of the boxes containing the eggs with cheesecloth secured by a rubber band or string. Transfer to a flowerpot cage (as in the figure) each kind of larvae which you have collected, as well as those which hatch from eggs. The flowerpot is full of loose soil; inside the lamp chimney is a branch of the tree upon which the eggs or larvae were found; the top of the chimney is covered with cheesecloth and secured with a rubber band to prevent the escape of larvae or adults.

Keep a day-to-day record of the development of the insect from the egg or the larva to the adult stage. The moths or butterflies will probably lay their eggs soon after they leave the pupae. These eggs probably will not hatch into larvae. Why?



Cornelia Clarke

Fig. 6

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[1] Projects 11 and 12 were adapted from "A Novel Hobby," by C. F. Greeves Carpenter, in the *Nature Magazine*, January, 1930.

If any do hatch, keep a careful day-to-day record of development as a check upon the first set of observations. Save a few eggs and at least one larva and a pupa to be placed with the adult in a permanent exhibit.

PROJECT 12. TO MAKE A PERMANENT EXHIBIT OF LIFE HISTORIES OF INSECTS

Procedure. Secure three small wide-mouthed glass vials of uniform size for each kind of insect. Place two eggs in one bottle, and fill the bottle with alcohol. From the larvae and the pupae which develop from the preceding project preserve a larva and the corresponding pupa in alcohol in the second and third bottles. When the adult moths or butterflies emerge from the pupae, allow them plenty of room so that they will not injure their wings or antennae while they are drying and maturing. Kill the butterfly or moth by putting it in a covered jar with a piece of cotton soaked in chloroform. Mount the adult specimens thus: Cut in the cover of a cardboard box a slit a little larger than the size of the insect's body, and let the body of the insect extend through this opening, while the wings rest on the cardboard. With your fingers carefully spread the wings fully on both sides. Place a narrow strip of paper across the wings on each side and parallel with the body. Pin the paper firmly to the cardboard, placing the pins near but not through the wings. After three days your specimen will be ready for permanent mounting.

Assemble the various life histories you have prepared, thus: Fill a cigar box full of cotton batting pulled apart so as to be soft and of uniform thickness. Place in order, left to right, the bottles containing respectively the eggs, the larvae, and the pupae. At the right of these place the corresponding adult moth or butterfly. By means of insect books find out the names of your specimens. On a small card typewrite the scientific name and the common name of your specimen; and also, from your notes of the preceding project, state the number of days required for the insect to develop from each stage into the next. Include also on this card any other interesting facts which you learned from your observations. Place this card beside or under your line of specimens. Paste a sheet of cellophane over the box. The cellophane cover should press against the bottles and the butterflies firmly enough to hold them in place.

NAME-- DATE-----------------

*EXPERIMENT 54. THE FISH

Problem. What are some of the characteristics of a living fish?

Materials. Small live fish in a jar of water; preserved fish or a fresh fish from the market; sharp-pointed scissors.

Procedure and observations. Observe the live fish. In the space below make a sketch of it as seen from the side. Label the eyes, mouth, jaws, nostrils, gill covers (opercula), and fins. Compare its external features with those in the figure.

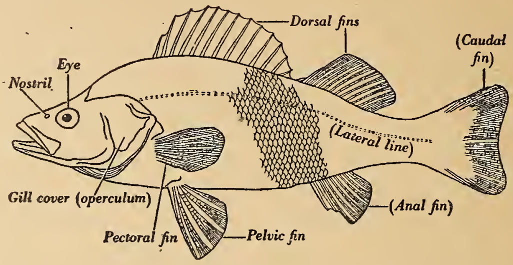


Fig. 1

How many fins has it? ------- What fin or fins does it use in stopping? ----------- ------------------------- What fin or fins does it use mostly in swimming? ------ -------------------------------- Can the fish remain motionless without moving the fins? ------- What fins are in pairs? --

What are the fins along the dorsal line used for?

Are the scales separate, or does each extend partly over the next, like shingles on a roof?

Can the fish move its eyes? ------- Has it eyelids? ------- What advantage does the fish derive from having its eyes placed as they are?

Pull away from the head the gill covers of the preserved fish or the fresh fish. Note how the gills are attached. Cut away the gill covers. How many gills are there on each side? -------

Note the filaments, or gill threads. How does their structure provide a great amount of surface?

Why is this great amount of surface necessary?

Which way do the gills point, toward or away from the mouth? ____________________________

What advantage can you see in this arrangement?

Note on the inner edge of the gill arch the bony projections. These are gill-rakers, which strain out food and catch solid objects that might injure the gills. Make a sketch of the head, showing the location of the gills. Make a separate sketch of a gill, showing the parts described.

EXPERIMENT 55 (OPTIONAL). INTERNAL STRUCTURES OF A FISH

Problem. What are some of the internal organs of a fish?

Materials. Preserved fish; sharp-pointed scissors.

Procedure and observations. Slit the lower abdominal wall of the fish, beginning with the anus (just in front of the anal fin) and cutting toward the head. Make another cut at right angles upward at each end of the cut you have made, so that the side wall of the abdominal cavity can be lifted up to reveal the organs. Identify as many as you can of the organs shown in Fig. 2.

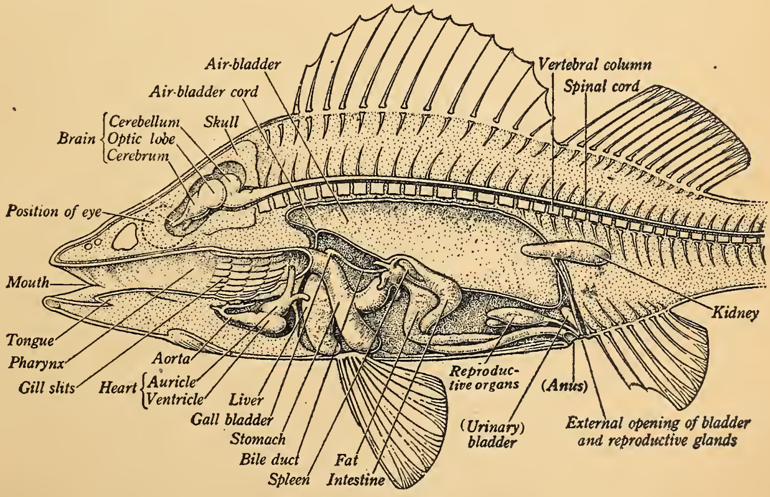


Fig. 2. Internal organs of a fish

After Hegner, *College Zoology*. Courtesy of The Macmillan Company

GUIDE QUESTIONS FOR STUDY. FISH

[Text pages 204–211]

1. What adaptations fit the fish for life in the water?

2. What does "homologous" mean?

What fins of the fish are homologous to the arms and legs of man?

3. Name several of the most important food fish of the world.

*EXPERIMENT 56. THE FROG

Problem. What are the characteristics of the frog?

Materials. Live frog; jar of water; preserved frog; dissecting instruments.

Procedure and observations. 1. *General adaptations.* What is the color of the frog? _______ _______ Is this color an advantage or a disadvantage? ________________________ Why?

What advantage is there in having the ventral surface colored as it is?

Put the live frog in a jar containing five or six inches of water. As it floats, note what parts of the body appear above the water. Put the water line in Fig. 3 and label the structures which you observed above the water line. Of what advantage to the frog is the fact that it floats in this position?

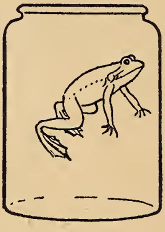


Fig. 3

Place the preserved frog so that it is facing you. Do you think it is possible for the frog to see an object directly in front of it? _______ Now turn the frog around, so that its back is toward you. Note the position of the eyes. Do you think it probable that the frog can see directly behind it? _______ How many eyelids does the frog have? (Use a preserved specimen to make sure you are right.) _______ How do they differ from those of man?

Find the tympanic membrane just behind the eyes. To what part of your ear does it correspond?

2. *Locomotion.* What three methods of locomotion does the frog use?

Compare the front and hind legs of the preserved frog as to

(1) *Length*

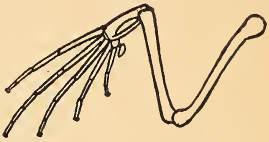
(2) *Uses*

(3) *Number of toes*

(4) *Amount of webbing*

Remove the skin from one hind leg. Note the large muscles. Examine one muscle closely to find where and how it is attached. Add this muscle to Fig. 4. How does the length of the ankle and toes compare with the length of the leg from knee to ankle?

Fig. 4



Of what advantage may this adaptation be?

3. *The mouth.* Try to get a live frog to catch a fly or other insect, if you can find one; or dangle a bit of meat in front of it. (A frog will not try to eat an object that is motionless.) Watch its actions. How does the frog secure its food?

Open the mouth of the preserved frog. (If it will not open readily, cut the skin at the angles of the jaw.) Describe the shape of the tongue and the position in which it is attached.

What advantage does the frog derive from having so large a mouth?

Do you find any teeth along the edge of the upper jaw? _______ Along the edge of the lower jaw? _______ In the roof of the mouth? _______ Describe any teeth you find.

Look closely on the outside of the head for the nostrils. Using the preserved specimen, pass a probe or a straw into one nostril. Where does the probe reappear?

Open the mouth of the frog. What are the two openings in the roof of the mouth?

In the throat note the wide opening to the esophagus, or gullet, down which food passes. Between this opening and the tongue you will see a ring of muscle, in the middle of which there is a small vertical slit (the glottis). To what does this opening lead?

Near the angle of the upper jaw find an opening. Pass a straw or a probe into it. Where does the probe reappear?

The passage you have followed is the Eustachian tube. Can you suggest what function it may serve?

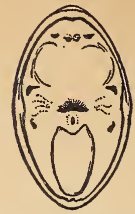


Fig. 5. Mouth of frog

Label the structures indicated in Fig. 5.

4. *Internal structures.* Remove the skin from the ventral side of the abdomen. Note the many blood vessels in the skin. Can you suggest a function which they may serve?

With the scissors cut through and remove the muscles which make up the body wall. Keeping the point of the scissors high so that you will not injure internal organs, cut through the muscles and bones up to the throat.

Is the heart farther anterior (toward the head) or farther posterior than yours? (Note the position of the heart with reference to the arms.)

How many lobes has the liver? _______ Where is the gall bladder?

Trace the organs of the digestive canal. On which side of the body is the stomach?

Is the small intestine straight, slightly coiled, or much coiled? ____________________ Note the thin membrane (mesentery) that holds the intestine in place. Are there blood vessels in it? _______ Find the spleen, a small, round body attached to this membrane. Does it seem connected with any other organ? ______ If so, with what organ? ____________________

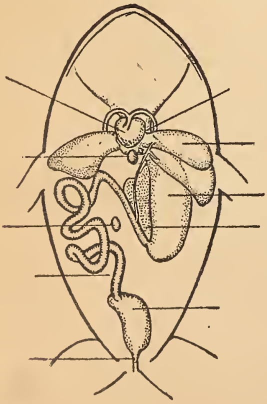


Fig. 6

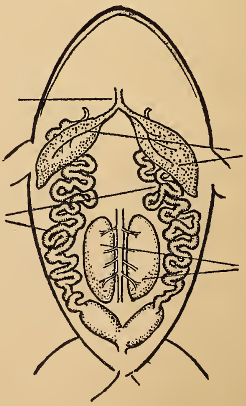


Fig. 7

Label in Fig. 6 the organs you have found thus far.

Where are the lungs?

Find the kidneys, large dark bodies fastened along the back. Near them you may find irregular finger-like fat bodies. Their presence will depend on the time of year the frog was caught. Why?

Label the organs shown in Fig. 7.

5. *Nervous system.* Now remove the internal organs. Along the back find several large white cords which come from between the vertebrae of the spinal column. These are nerves. Trace them as far as you can. Where do these nerves go?

What muscles do they probably control?

Now turn the frog over, so that you are looking at the top of its head. Remove the bone carefully from the top of the skull, exposing the brain cavity. Notice the membrane covering the brain.

Can you find blood vessels in this membrane? _______

What possible uses do you think this membrane may have?

Locate the various parts of the brain by comparing your specimen with Fig. 8. Consult the figure on page 426 of the textbook for the names of the parts of the brain, and label Fig. 8.

6. *Circulation.*[1] See Experiment 76 on page 125 of this workbook.

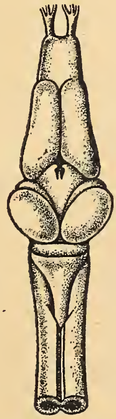


Fig. 8

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[1] *To the Teacher.* You may wish at this time to perform Experiment 76 on page 125, "Circulation in the Frog," and to include it as part 6 of this experiment.

EXPERIMENT 57 (OPTIONAL). INTERNAL STRUCTURES OF THE FROG

Pupils may make a choice of one or more of these problems:

1. Trace the blood vessels leading from the heart. Make a sketch.

2. What differences are there in the internal structures of the male and the female? Make sketches to illustrate your conclusions.

3. What causes the hump in the frog's back? You will have to study the structure of the bony skeleton to answer this problem. Make a sketch.

GUIDE QUESTIONS FOR STUDY. AMPHIBIANS

[Text pages 211–218]

1. What are the distinguishing characteristics of the amphibians?

2. List as many amphibians as you can.

3. Complete this outline of the steps in the metamorphosis of the frog:

(1) Eggs laid in water.
(2) Eggs hatch (eight to ten days).
(3) Young tadpoles attach themselves to water weeds by means of a sucking disk; are nourished by
(4)

4. Of what economic importance are amphibians?

5. How does a tadpole differ from a frog? Answer by completing the following chart:

	TADPOLE	FROG
Kind of mouth . . .		
Food used		
Organs of respiration		
Length of intestine .		

GUIDE QUESTIONS FOR STUDY. REPTILES

[Text pages 218–225]

1. What are the distinguishing characteristics of the reptiles?

(1)

(2)

(3)

2. How many different kinds of reptiles can you name?

3. State three facts which you think should be generally known about snakes.

4. State two protective adaptations of turtles.

PROJECT 13. TO MOUNT A SKELETON

Procedure. The method here described for mounting a turtle skeleton would serve for mounting the skeleton of any small animal. Secure a medium-sized turtle and kill it with ether or in some other humane way which will not injure the skeleton. Saw through the lower shell at both sides, and carefully remove the lower plate from the upper. Cut off as much flesh as possible without disturbing any of the bones. Place both plates in water which is slightly warm, and leave them there for a week or until the flesh has decayed sufficiently so that it slips easily from the bones. Carefully remove the flesh from the bones, taking care not to lose any of the bones. If you object to handling the decaying flesh with your bare hands, wear rubber gloves. If you remove the various bones, lay them together in the same relative positions that they had in the body. Be sure that the bones are entirely clean. If you experience difficulty in removing the last bit of flesh, put the bones into an aquarium with goldfish; the fish will quickly eat the small particles of flesh without injuring the skeleton. Mount the skeleton, using collodion or transparent lacquer to cement the bones together. Attach the bottom shell plate to the upper one in its original position, using small brass hinges. Mount the entire skeleton on a block of wood with a strong wire for support. After the mounted skeleton is thoroughly dry, cover the entire surface with a coat of lacquer; this will keep the skeleton clean and will enable you to dust it easily. In dusting it, use a camel's-hair brush in place of a dusting cloth.

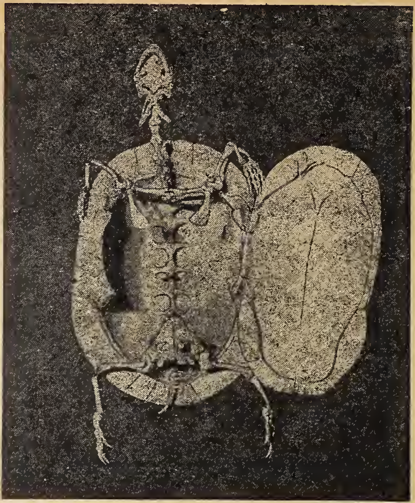

M. E. Van Ells

Fig. 9

EXPERIMENT 58. THE BIRD

Problem. What are some characteristics of a living bird?

Materials. A chicken, canary, pigeon, or any other bird.

Procedure and observations. What differences do you find in the feathers on different parts of the bird's body?

How are the wings adapted for flying?

Watch a bird flying, and try to determine how it moves the wings to enable it to move forward. Describe the motion.

For what purposes does the bird seem to use its tail?

Look closely at the feet. How many toes are there? _______ Describe their shape and arrangement.

What shape is the beak?

How does the bird drink?

Do the eyes seem to have the same parts as your eyes? _______ Describe them.

If you watch the bird closely, you can see it move the third eyelid (nictitating membrane). Where is this eyelid attached?

Look for nostril openings. Where are they? _________________________________ Ruffle the feathers just above and behind the eyes to find the ears. Describe them.

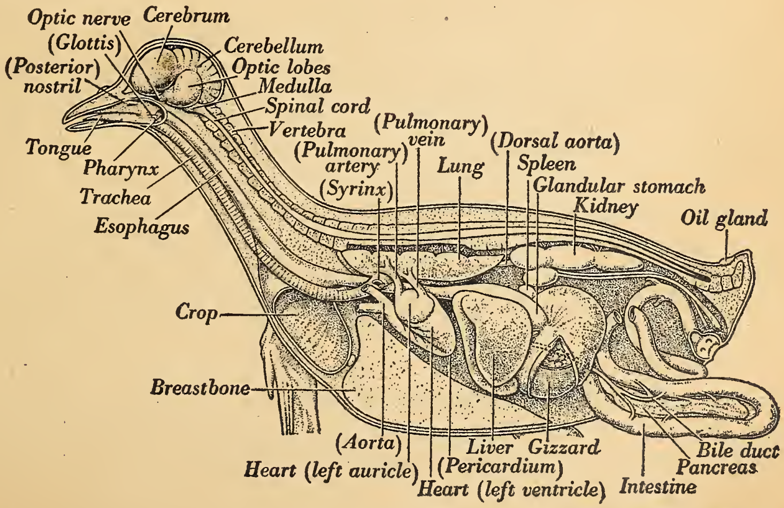
Make a sketch of the head to show the shape of the beak, and the location of the eyes, ears, and nostrils. Label each.

EXPERIMENT 59. INTERNAL STRUCTURES OF A BIRD

Problem. What are the internal structures of a bird?

Materials. A chicken, with feathers removed, ready for dressing; knives; bone shears, if available.

Procedure and observations. Make a cut through the skin and fat an inch or so below the breastbone. Then with a heavy knife or the bone shears cut through the ribs on each side as far as the wings. Lift the front of the chicken so that you can see the internal organs. Identify them by consulting Fig. 10.



From Meier and Shoemaker, *Essentials of Biology*

Fig. 10

EXPERIMENT 60 (OPTIONAL). FEATHER STRUCTURE

Problem. What is the structure of a feather?

Materials. Feathers from chicken, turkey, or other bird; hand lens; microscope; slide.

Procedure and observations. Note that the feather is made up of a quill to which are attached fine branching filaments that make up the broad part of the feather. Examine these filaments with the hand lens. What do you observe about their structure?

Tear the feather apart in one or two places; then try to smooth it back so that it is again whole. Examine a piece of the feather closely with the hand lens or the microscope. What structures do you find which account for the fact that a ruffled feather is easily smoothed out?

Make a sketch or sketches of parts of a feather, showing what you observe about its structure.

EXPERIMENT 61 (OPTIONAL). HOW A BIRD PERCHES

Problem. How can a bird sit on a wire or a branch without falling?

Materials. A piece of string about three feet long.

Procedure and observations. Tie one end of the piece of string around the tip of your middle finger. Pass the string between the fingers, across the back of the hand, and behind the elbow. Keep the fingers and the arm straight, and hold the string firmly against the arm above the elbow. Now place your hand on the back of a chair or on a broom handle, and bend your elbow. What happens to your fingers?

This experiment illustrates how a bird's foot and the attached muscles are adapted to hold it to the perch, even when the bird is asleep. Can you explain why it is true that the more the bird settles down on the perch, the tighter the toes hold it to the support?

GUIDE QUESTIONS FOR STUDY. BIRDS

[Text pages 225–231]

1. What evidence is there to indicate that the ancestors of birds were reptiles?

2. What are the distinguishing characteristics of birds?

(1)

(2)

3. State two facts which tend to prove that the structures of various kinds of birds are well adapted to the bird's environment.

4. State two theories which are meant to explain why birds migrate.

5. Name six enemies of birds.

PROJECT 14. TO COLLECT ANIMAL SKULLS FOR THE BIOLOGY MUSEUM

Procedure.[1] A museum collection of animal skulls is one to which each class can make a contribution. In the course of several years the combined contributions of all the classes will result in a fine collection.

Heads of several different kinds of large animals can be secured from the meatman.

Remove as much of the skin from the head as you can. Cut away the tongue and as much flesh as possible without injuring the bone in any way. Remove the brain through the small hole in the under-side of the skull by rinsing with running water.

Immerse the skull in strong alcohol to dry it; after two days transfer it to naphtha for two days. **[CAUTION: Avoid inhaling naphtha fumes, as they are slightly poisonous.]** Remove it from the naphtha and allow it to dry until all the naphtha has evaporated. When it is thoroughly dry, soak it in soft water or distilled water for a length of time which varies with the size of the animal—for example, an hour for very small animals such as shrews and the smallest bats, six hours for mice, twelve for rats, and twenty-four for larger forms. Next put the skull into a pan with two parts of water and one part of commercial peroxide of hydrogen, enough to float the skull. Heat the liquid to the boiling point and allow the smallest skulls to boil for about three minutes, the mice's skulls for from eight to ten minutes, the rats' skulls about fifteen minutes, and larger skulls for a longer time. Cool the skulls slowly by allowing cold water to trickle into the pan.

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[1] Adapted from A. B. Howell, *Journal of Mammalogy*, Vol. I (1919), pp. 40–41.

The skull is now ready to be cleaned of all the flesh. Work carefully so as not to injure the bones.

Make an exhibit of the skulls. Beside each skull place a card upon which you have written the phylum, the class, the order (see pages 232–234 of textbook), and the family, genus, and species, if you know them or can learn what they are. Also, include, in the information you give, the important characteristics of this animal and such other information as you consider valuable or interesting, such as the date and the place where the animal was found.

PROJECT 15 (OPTIONAL). TO MAKE A CHART OF MAMMALS OF VARIOUS ORDERS AND CLASSES

Procedure. A chart showing the characteristics of various orders and families of mammals would be a valuable addition to the permanent equipment of your classroom.

Collect good pictures of various kinds of animals. You will find many fine pictures in national-park bulletins and in magazines, especially the *Nature Magazine* and the *Natural History Magazine.* Other pictures may be photographs which you yourself have taken. Sort these first according to orders, then according to the families or even genera and species. For example, in an exhibit of the Carnivora you might secure and group together pictures of several different members of the dog family, the cat family, and the bear family. You might have several different kinds of dogs to group together as a smaller group within the larger group of the family. This larger group in turn would be a smaller group within the greater group of animals representing the order.

GUIDE QUESTIONS FOR STUDY. MAMMALS

[Text pages 231–242]

1. What are the distinguishing characteristics of mammals?

2. Give four illustrations showing how the leg structures of different mammals are adapted to special functions.

3. Give four illustrations of adaptations of mammalian structures which serve as means of defense.

4. Complete the following chart on mammals:

Principal Orders	Examples	Distinguishing Characteristics
Rodentia . .		
Carnivora . .		
Ungulata . .		
Primates . . .		

Which of these four orders of mammals is most important to man? ____________________

__________ Why?

Which group is most harmful? __________________________ Why?

5. Put a check before the name of each of the following animals which is a mammal. Write **H** after each mammal that is herbivorous (a plant-eater); **C** after each one that is carnivorous (flesh-eater); and **O** after each one that is omnivorous (eater of both plants and animals).

____ rattlesnake _____
____ elephant _____
____ chipmunk _____
____ Gila monster _____

____ horse _____
____ salmon _____
____ rat _____
____ cow _____

____ robin _____
____ lion _____
____ giraffe _____
____ bat _____

____ sheep _____
____ deer _____
____ man _____
____ seal _____

EXPERIMENT 62 (OPTIONAL). BONE STRUCTURE

Problem. What are the various parts of a bone?

Materials. A leg bone (ask the meatman to make several lengthwise cuts through the ends of the bone about two inches deep); meat saw.

Procedure and observations. Remove the flesh from the bone, and examine the surface of the bone carefully. Can you determine what sort of covering there is over the bone beneath the flesh?

Examine the joint. What holds the two bones together?

Draw a sketch in the space below to show how this fastening is attached to the bones. Are the joint surfaces rough or smooth to the touch? ------------------- Can you see any advantage in this condition?

With the meat saw cut horizontally at the lower ends of the lengthwise cuts, and remove the sections of bone one by one. You should be able to locate in these sections hard bone, spongy bone, yellow marrow, and white marrow. Draw a sketch showing the locations of these structures.

EXPERIMENT 63 (OPTIONAL). WHAT ARE THE VARIOUS KINDS OF JOINTS?

Problem. What are the various kinds of joints?

Materials. Head of a chicken or other fowl; a chicken leg with a knee joint; the shoulder or hip joint of a fowl or other animal.

Procedure and observations. Boil the head until you can remove all the flesh from the bone. Describe the structure of the skull.

In what different ways can you move the hip joint?

The knee joint?

The ankle joint?

Are motions in certain directions possible with any of these joints which are not possible with either of the others?

EXPERIMENT 64 (OPTIONAL). ANIMAL MATTER AND MINERAL MATTER IN THE BONES

Problem. What are the functions of the matter that composes the bones?

Materials. Two leg bones or rib bones of a chicken; hydrochloric acid; test tube; Bunsen burner and stand.

Procedure and observations. 1. *Animal matter.* Put one of the bones into the test tube and cover it with water to which you have added about a quarter as much hydrochloric acid as the water. The acid combines chemically with the lime of the bone, leaving the animal matter. After two days remove the bone, wash it, and try to bend it. Does it bend more or less easily than before the mineral matter was removed? _______

Conclusion. What, then, should you say is the function of animal matter in the bones?

2. *Mineral matter.* Place the other bone over the flame of the burner until all the animal matter of the bone has been consumed. After the bone has cooled, try to bend it. Does it bend more or less easily than before the animal matter was removed?

Conclusion. What, then, should you say is the function of the mineral matter in the bones?

GUIDE QUESTIONS FOR STUDY. THE HUMAN SKELETON

1. What is the longest bone in the human body (Fig. 11)? ______________________________

2. What three regions of the skeleton are box-like structures which protect delicate organs?

3. Name two groups of bones which together act as levers.

4. How is the backbone constructed?

5. How is the skull constructed?

Exercise on Biological Principles. From your study of the skeletons of the different phyla of animals what facts can you cite which support the following principles?

1. Complexity of structure goes hand in hand with division of labor; that is, in general, the more complex the structure of an animal, the greater is the degree of its division of labor.

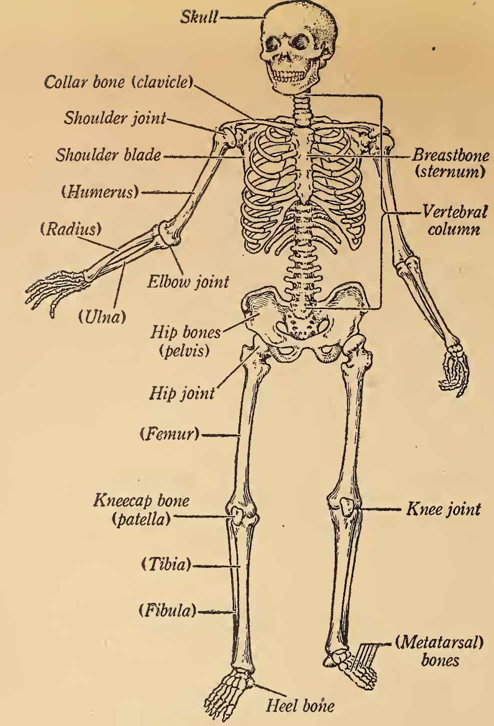


Fig. 11

2. The skeleton of an animal bears a close relation to its habits.

Self-test on Biological Terms. Be sure you can define these words. Check your definitions with those in the Glossary of your textbook.

Amphibia
appendage
cartilage
chordate
homologous
mammal
migration
reptile
vertebra
vertebrate

NAME_______________________________________ DATE_________________

GUIDE QUESTIONS FOR STUDY. SOIL CONSERVATION

[Text pages 246–256]

1. In what ways are plants dependent on soil?

In what ways do plants improve the soil?

2. How do three different kinds of soil bacteria benefit the soil?

3. Why are legumes important in crop rotation?

4. In what ways does erosion by water ruin land for agriculture?

5. Under what conditions can wind be an important factor in the erosion of farm land?

6. List and briefly describe six ways of preventing erosion.

(1)

(2)

(3)

(4)

(5)

(6)

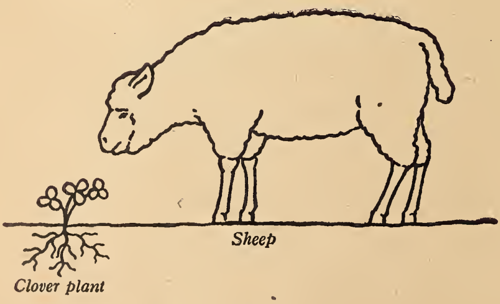
7. How does erosion of farm land in one part of the country affect people in all parts of the country (social implications)?

*EXPERIMENT 65. THE NITROGEN CYCLE

Problem. Are there special growths upon the roots of clover or alfalfa which are not found on the roots of dandelion or lawn grass?

Procedure and observations. Carefully remove from the ground several clover or alfalfa plants, together with several dandelion plants or clumps of grass. Wash all the soil from the roots and examine them carefully. What differences do you observe?

Read pages 248–250 of the textbook, on "Soil bacteria." When you feel that you understand the nitrogen cycle, complete the figure by adding labels or other labeled sketches.



PROJECT 16. TO MAKE A STUDY OF CROP PESTS AND CONTROL MEASURES

Problem. What are some important facts about the most serious crop and animal pests in your state?

Materials. Bulletins and pamphlets from your state department of conservation or your state agricultural college.

Procedure. There are a number of different studies which you might make, such as the following:

1. A study of the spread of a certain pest from year to year over your state.
2. A study of the chief centers of attack of a number of pests.
3. A study of the relative amounts of damage done by a certain pest over a period of ten or twenty years, estimated in dollars per year.
4. A comparison of the relative importance of several pests measured in the estimated damage in dollars over a certain period of years.
5. A study of the life history of one or more pests.
6. A study of the measures which are being taken to combat a certain pest.

Studies like 1 and 2 can be effectively presented by drawing an outline map of your state, and by then using, for 1, some device such as that illustrated in the figure on page 257 of *Everyday Biology*, and, for 2, a sketch of each pest, or something else appropriate to represent the pest, placed in its appropriate spot on your map.

Studies like 3 and 4 can be effectively presented with "telefacts" graphs, such as those on pages 483 and 534 of *Everyday Biology*.

Studies of life histories can be effectively presented in a series of sketches of the sort represented in the figures on pages 258 and 647 of *Everyday Biology*.

Make your diagrams or sketches on separate sheets of paper, so that they may be displayed on your classroom or school bulletin board.

GUIDE QUESTIONS FOR STUDY. ORGANISMS OF ECONOMIC IMPORTANCE

[Text pages 256–269]

Make a summary of the important facts about these pests: potato beetle, fruit fly, San Jose scale, wheat rust, cottony-cushion scale, cotton-boll weevil, codling moth, Texas cattle fever, animal lice, hog cholera, potato wart.

Name of Pest	Its Host or Hosts	Means of Fighting It
1. *Corn-borer*	*Corn*	*Burning infested fields, plowing under, quarantine*
2.		
3.		

Name of Pest	Its Host or Hosts	Means of Fighting It
4.		
5.		
6.		
7.		
8.		
9.		
10.		
11.		
12.		

PROJECT 17. TO STUDY ENEMIES OF THE FOREST

Procedure. Secure from your state or provincial department of conservation and the United States Forest Service or the Forests Branch of the Department of Mines and Resources of Canada materials dealing with insect pests and plant pests which attack forests and containing facts about forest fires. Present your facts in graphs, tables, or charts in the space below.

NAME_________________________________ DATE_________________

GUIDE QUESTIONS FOR STUDY. CONSERVATION OF FORESTS

[Text pages 270–280]

1. List important values derived from forests.

2. What is the meaning of the term *forest conservation*?

3. List enemies of the forest, and state the nature of the damage done by each.

4. What arguments could you advance to convince someone that most wild flowers should not be picked?

GUIDE QUESTIONS FOR STUDY. CONSERVATION OF BIRDS

[Text pages 280–286]

1. List ways in which birds are of value to man, and give several examples of birds which assist in each of these ways.

2. What reasons can you give to account for the fact that some species of birds have become extinct?

3. Give four important provisions of various laws for bird protection.

GUIDE QUESTIONS FOR STUDY. CONSERVATION OF OTHER ANIMALS

[Text pages 286–294]

1. State several reasons why certain animals should be protected.

2. Write at the left the names of rodent enemies of your vicinity and opposite each the kind of damage it does.

3. What sorts of laws have been passed for the conservation of various kinds of fish?

4. What kinds of water life other than fish are protected, and how are they protected?

GUIDE QUESTIONS FOR STUDY. NATIONAL PARKS AND THE CIVILIAN CONSERVATION CORPS

[Text pages 294–299]

1. State several reasons for establishing and maintaining national parks.

2. State four biological problems which would be appropriate for study in national parks. For example, one such problem might be to classify the animals in one of the national parks.

3. What activities of the Civilian Conservation Corps aid in conservation?

PROJECT 18. TO STUDY A NATIONAL PARK

Procedure. Secure from the National Park Service in the Department of the Interior of either the United States or Canada, and from the railroad companies, bulletins on some one of the national parks, preferably one which you expect or at least hope someday to visit. Make a bulletin-board poster on a large sheet of cardboard. Draw an outline map of the state or province in which the park is located, indicating the location and area of the park. Draw a large outline map of the park itself, and locate on it the principal points of interest. Print the names of these features, or, if you are clever at sketching, make small sketches which indicate the nature of the features. For example, if you were studying Yosemite, you might include little sketches at the proper places to indicate Half Dome, El Capitan, the bear-feeding spot, the Firefall, Camp Curry, Glacier Point, Yosemite Falls, and so on. Beneath or around your large map you can paste interesting pictures, especially those indicating the characteristic plant life and animal life, clipped from the bulletins. Make a list of the most important plants and animals which are to be found in the park, and include interesting facts about them. Your poster when completed will be a valuable addition to the permanent equipment of the biology department.

Prepare a ten-minute talk on this park, to be delivered before your classmates. Write the topics for your talk in the space below.

Special Reports. Select one of the following subjects for a ten-minute report in class. Write the topics for your talk in the space at the bottom of this page.

1. Discuss the history of the use of the forests and lands of your locality, your state or province, or your country.
2. What are the most destructive insect pests of your vicinity? Do birds feed on these insects? If so, what birds?
3. Salt Lake City has erected a statue to the sea gull because of the help these birds gave in combating a grasshopper plague. Report more fully on this story.
4. What bird refuges or sanctuaries are there in your state?
5. What animals are protected in your state? For which animals are there brief hunting seasons? Are there any animals that are not protected which you think should be? Are there any harmful animals which should be destroyed? (Consult your state or provincial department of conservation.)
6. What birds once abundant in your state have decreased greatly in numbers? What factors help to account for their disappearance? Look in an encyclopedia or a book on birds under "egret," "passenger pigeon," and "golden plover."
7. Write to the United States Department of Agriculture or the Canadian Minister of Agriculture for the annual pamphlet containing a summary of the laws relating to hunting seasons.
8. How is paper made? What forest products other than those named on pages 272–274 of *Everyday Biology* can you list? What is celluloid? excelsior?
9. Find out as much as you can about the biological explorations of William Beebe, Martin Johnson, Carl Akeley, John Ernest Williamson, and Roy Chapman Andrews. (*Who's Who in America* and *American Men of Science* are possible sources of information.)

NAME____ DATE________________

GUIDE QUESTIONS FOR STUDY. SECURING FOOD

[Text pages 302–313]

1. In what ways do green plants, symbiotic plants, parasitic plants, and saprophytic plants secure food?

(1) *Green plants*

(2) *Symbiotic plants*

(3) *Parasitic plants*

(4) *Saprophytic plants*

2. What special adaptations for food-getting does each of these animals have?

(1) *Amoeba* ___*No special structures*____

(2) *Paramecium* ___*Funnel-shaped groove;*____

(3) *Sponge*

(4) *Hydra*

(5) *Earthworm*

(6) *Snail*

(7) *Crayfish*

(8) *Insects*

(9) *Fish*

(10) *Frog*

(11) *Reptile*

(12) *Bird*

(13) *Mammal*

GUIDE QUESTIONS FOR STUDY. FOODS

[Text pages 313–317]

1. Complete the following outline:

FOODS

I. Energy foods

A.

B.

C.

II. Non-energy foods
  A. Essential

    1.

    2.

    3.

  B.

    1.

    2.

    3.

2. What purposes do foods serve for the body?

(1)

(2)

(3)

3. Into what forms of energy is food energy transformed?

Problem. What are the characteristic tests for various food substances?

1. *Starch* (*Materials*). Two test tubes; cornstarch; sugar; iodine solution; burner.

Procedure and observations. Put into one test tube a little cornstarch and into the other (as a control) a small amount of sugar. Add water to the same level in each of the tubes. Heat both test tubes equally. Cool the solutions, and put a few drops of iodine solution in each. Describe the changes you observe in the starch that you do not see in the control substance, which contains no starch.

Any substance containing starch, when treated in this way, will give this characteristic color test, which a substance that does not contain starch will not give.

2. *Sugar* (*Materials*). Two test tubes; commercial grape sugar (dextrose or glucose) or honey; some substance, such as cooked white of egg, which contains no sugar (as a control); Fehling solutions A and B; burner.

Procedure and observations. Put into one test tube a little of the sugar or glucose and into the other some of the white of egg. Add to each an equal quantity of a mixture of Fehling solutions A and B. Heat both test tubes equally. Describe the difference between the appearance of the contents of the tube containing sugar and that of the contents of the tube containing no sugar.

3. *Protein* (*Materials*). Two test tubes; cooked white of egg, which contains considerable protein; some substance, such as sugar, which contains no protein (as a control); nitric acid; ammonia; burner.

Procedure and observations. Put into one test tube some white of egg and into the other the sugar. Add water to the same level in both tubes. Boil the contents of both tubes for the same length of time. Add to each a small amount of nitric acid. What happens?

Now to each add a little ammonium hydroxide, *a drop or so at a time.* What do you observe in each tube?

Any substance containing protein, when treated in this way, will give this characteristic color test, which a substance that does not contain protein will not give.

4. *Fat* (*Materials*). Lard or butter; some substance, such as a cube of sugar, which contains no fat (as a control); sheet of paper.

Procedure and observations. Rub first the butter or the lard on the paper; then rub the sugar on the paper. Hold the paper to the light. Describe the effect which each substance produced.

Any substance containing fat, when treated in this way, will give this characteristic test, which a substance that does not contain fat will not give.

EXPERIMENT 67 (OPTIONAL). THE ENERGY FOODS CONTAINED IN CERTAIN COMMON FOODS

Problem. What energy foods are contained in common foods?

Materials. Test tubes; water; iodine crystals or tincture of iodine; Fehling solutions A and B; nitric acid; ammonia; paper; burner; samples of different foods, such as bread and meat.

Procedure and observations. Test each food in turn for starch, sugar, protein, and fat.

Write in the following chart the names of the foods you tested, placing in each column a + if your results show that the food contains the substance indicated at the head of the column, and a – if it does not.

NAME OF FOOD	STARCH	SUGAR	PROTEIN	FAT

Compare your results with those obtained by other members of the class. In all cases in which various members disagree the tests should be carefully repeated until you are all sure which are the correct answers.

EXPERIMENT 68. CALORIE REQUIREMENTS

Problems. How many Calories do I need in one day? How many Calories do I secure from the food I eat?

Procedure. Calculate the number of Calories you use in an average day, using the following table. For example, if you weigh 120 pounds and sleep 8 hours, the first calculation would be $\frac{1}{2} \times 120 \times 8 = 480$; that is, you use 480 Calories.

Sleeping or lying down . . . . $\frac{1}{2}$ C. per pound per hour ______

Sitting, reading, studying . . . . $\frac{2}{3}$ C. per pound per hour ______

Standing . . . . $\frac{3}{4}$ C. per pound per hour ______

Walking . . . . $1\frac{1}{2}$ C. per pound per hour ______

Active exercise . . . . 2 C. per pound per hour ______

Total Calories for 24 hours ______

Make a record in the table below of the food you ate yesterday (if that was an average day). Use the food tables on pages 322–323 of *Everyday Biology* to compute the number of Calories you consumed.

FOOD	CALORIES			
	Protein	Fat	Carbo-hydrates	Total
Total for the day				

How does the number of Calories you need in one day compare with the number you take in?

If the number you take in differs greatly from the number required, can you account for this difference?

According to most authorities, the proteins in our diet should furnish from 12 to 15 per cent of the total Calories; the fats should furnish about 20 per cent; and the carbohydrates the rest.

What per cent of your Calorie total is furnished by proteins? ____________ By fats? _____

By carbohydrates? _________

GUIDE QUESTIONS FOR STUDY. FOODS

[Text pages 317–335]

1. How does protein differ in composition from carbohydrates and fats?

2. Complete this chart:

CLASS	EXAMPLES OF FOODS	USES TO THE BODY
Carbohydrates		
Fats		
Proteins . .		

3. State two reasons why milk is a valuable food.

4. Name foods which provide both vitamins and minerals.

5. Why is water necessary in the body?

6. What are the functions of flavors and condiments?

7. From the standpoint of a biologist what arguments would you give against the use of tea and coffee by girls and boys?

Self-test on Biological Terms. Be sure you can define these words. Check your definitions with those in the Glossary of your textbook.

Calorie
carbohydrate
carnivorous
food vacuole
incisor
ingestion
metabolism
molar
nutrient
parasite
protein
saprophyte
stimulant
vitamin

Exercise on Scientific Method (Making Inferences)

Procedure. Collect teeth or jaws of as many kinds of animals as possible, or visit a museum where such teeth and jaws are on display. Try to decide from the kind and arrangement of teeth the nature of the food of the animal (see the figure on page 312 of the textbook). Sketch or mount on cardboard the teeth or jaws, and write beside each sketch your inferences concerning the food habits.

PROJECT 19. TO MAKE A POSTER OR A CARTOON ILLUSTRATING CERTAIN FACTS CONCERNING FOODS

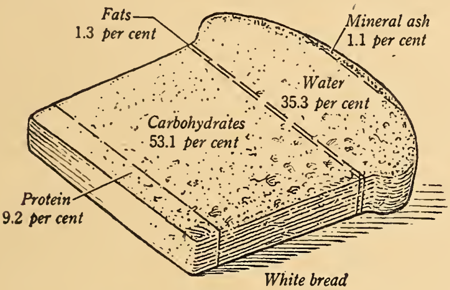
Procedure. Choose one of the subjects suggested below, or take some similar subject of your own selection. In the space at the bottom of this page make sketches for a poster or draw a cartoon (see page 327 of *Everyday Biology*) which could be used at a fair or convention to interest people, who perhaps have not studied biology, in some problems related to the foods we eat.

Foods Which Contain Starch (or protein, fat, or minerals)
Vitamins (to show some foods supplying each vitamin)
A Well-Balanced Meal

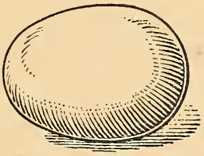
PROBLEM. TO SHOW THE RELATIVE PER CENTS OF VARIOUS NUTRIENTS IN SOME COMMON FOODS

Procedure. Complete the diagrams given in the figure by dividing each according to the proportions indicated by the per cents given in this table.[1] The diagram for white bread is completed as a model. Label each diagram.

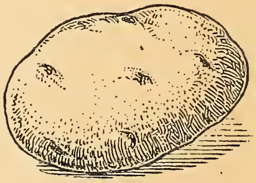
Food	Per Cent of Protein	Per Cent of Carbohydrates	Per Cent of Fats	Per Cent of Water	Per Cent of Mineral Ash
White bread	9.2	53.1	1.3	35.3	1.1
Egg	14.8	0.	10.5	73.7	1.0
White potato	2.2	18.4	0.1	78.3	1.0
Whole milk	3.3	5.0	4.0	87.0	0.7
Pork chop	16.9	0.	30.1	52.0	1.0
Beefsteak	18.6	0.	18.5	61.9	1.0
Green beans	2.3	7.4	0.3	89.2	0.8
Corn	3.1	19.7	1.1	75.4	0.7



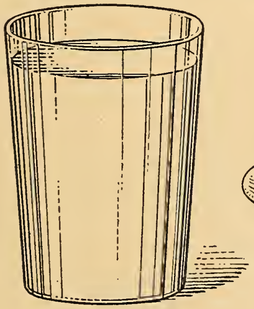
White bread



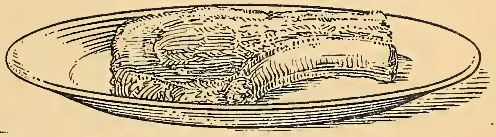
Egg



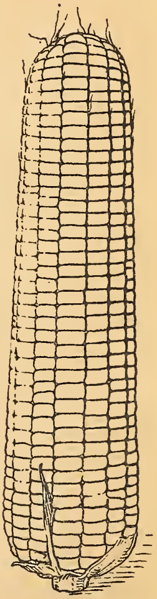
White potato



Whole milk



Pork chop



Corn

Beefsteak

Green bean

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[1] Data from United States Department of Agriculture, Bureau of Nutrition Investigations.

PROJECT 20. TO PLAN SOME SAMPLE BALANCED MEALS

Procedure. From the table on pages 322 and 323 of *Everyday Biology*, supplemented with the additional information given on page 325, plan the menus for one day's meals which will give you the correct number of Calories, which will give you the proper proportions of the three energy foods, and which will also supply the needed variety of vitamins. Indicate the portions to be served to a person of your age and habits.

PROJECT 21. TO STUDY THE EFFECTS ON RATS OR MICE OF CERTAIN DEFICIENCIES IN DIET[1]

Procedure. From a litter of white rats or white mice choose two which, in so far as you can determine, are in every way as nearly alike as possible. You should begin your experimental feeding of the animals as soon as they are weaned. A rat develops so rapidly that a three-year-old rat corresponds to a very old man; a six-months-old rat corresponds in development approximately to a person of your age. Feed cheese, lettuce, meat, and bread to both; feed one milk (the experimental factor) and the other (the control) water. As soon as you are able to detect any marked differences between your experimental subjects in appearance, weight, or any other characteristic, exchange their diets. Observe whether the differences tend to disappear when the diets are exchanged. Continue the experiment only until you are sure what the results of the difference in diet are; then put both rats on a complete, normal diet. Record your observations in the table on page 117.

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[1] Several pupils should carry on this project in order to provide a sufficient number of experimental subjects for adequate checks and controls.

	Date of Beginning of Experiment	Diet	Date When Difference Was Observed	Nature of Difference
Rat A				
Rat B				
Rat B				
Rat A				

Perform similar experiments with various items of the diet serving in turn as the experimental factor. Make a similar record of your experiments.

	Date of Beginning of Experiment	Diet	Date When Difference Was Observed	Nature of Difference
Rat A				
Rat B				
Rat B				
Rat A				

NAME____ DATE_________________

*EXPERIMENT 69. DIGESTION IN GERMINATING SEEDS

Problem. Does digestion of starch take place — that is, is starch changed to sugar — in germinating seeds?

Materials. Bean and corn seeds; sphagnum moss or sawdust; test tubes; tincture of iodine or iodine crystals dissolved in water; Fehling solutions A and B; burner.

Procedure and observations. Soak the seeds in water overnight; then plant them in moist sphagnum moss or moist sawdust. When they have germinated, grind some of the germinating seeds and also some of the dry seeds of the same kinds as a control. Test a sample of the germinated seeds and of the control for starch and for sugar (see Experiment 66, p. 110 in this workbook). Record your observations below.

1. Is starch present in dry corn seeds? ______ Is sugar present? ______

2. Is starch present in germinated corn seeds? ______ Is sugar present? ______

3. Is starch present in dry bean seeds? ______ Is sugar present? ______

4. Is starch present in germinated bean seeds? ______ Is sugar present? ______

Conclusion. Answer with a complete statement the question asked in the problem.

EXPERIMENT 70. DIGESTION IN PLANTS

Problem. Does diastase digest starch, that is, change it to sugar?

Materials. Test tubes; diastase; starch; warm water; tincture of iodine or iodine crystals dissolved in water; Fehling solutions A and B.

Procedure and observations. Put into one test tube a little starch. Add warm water and a little diastase. Into the second test tube, which is to serve as a control, put as much starch and warm water as in the first test tube, but add no diastase. Keep both tubes side by side in a warm place for an hour. Test the contents of each for both starch and sugar. Record your observations here.

In a mixture of starch, water, and diastase, is starch present? ______ Is sugar present? ______

In a mixture of starch and water, is starch present? ______ Is sugar present? ______

Conclusion. Answer with a complete statement the question asked in the problem.

GUIDE QUESTIONS FOR STUDY. DIGESTION

[Text pages 336–343]

1. What is meant by the statement that all enzymes are organic in nature?

2. Why must digestion by simple plants, such as bacteria, take place outside the cell?

3. Which of the Metazoa here discussed have certain cells that capture and digest food as if these cells were Protozoa?

4. What takes place in the cavity in *Hydra* which does not take place in the cavity in the sponge?

How do the differences in structure of the two animals account for these facts?

5. Under the name of each of the following animals list the digestive organs it has.

Flatworm	**Earthworm**	**Crayfish**	**Frog**	**Man**

Exercise on a Biological Principle. What facts can you state in support of the biological principle "In general, the higher in the scale of life an animal is, the more complex is its digestive system"?

EXPERIMENT 71. DIGESTION IN THE MOUTH

Problem. What changes does saliva bring about in starch?

Materials. Two test tubes; a little cornstarch; warm water; Fehling solutions A and B.

Procedure and observations. Put into your mouth a pinch of cornstarch. Can you note any change in its flavor after the starch has been in your mouth for a few seconds? ------- If so, describe the change. --

Remove the starch and the saliva, placing the mixture in a test tube. Put a little starch into another test tube for a control. Add the same amount of warm water to the contents of each test tube. The experimental factor here is saliva because it is the only factor which is present in one of the test tubes but not in the other.

Test the contents of both tubes for sugar. Record the results below.

1. Does the mixture of starch, water, and saliva contain sugar? ------

2. Does the mixture of starch and water contain sugar? ------

Conclusion. Answer the question asked in the problem.

EXPERIMENT 72. DIGESTION IN THE STOMACH

Problem. What is more effective in digesting protein: water, hydrochloric acid, pepsin, or a combination of water, pepsin, and hydrochloric acid?

Materials. Four test tubes; white of hard-boiled egg; pepsin; hydrochloric acid; water.

Procedure and observations. Into each of four test tubes put an equal small quantity of white of egg. To the first test tube add water enough to fill it about a fourth full. This test tube is the control. Dissolve pepsin in water; add this solution to the second test tube. To the third add water and a few drops of hydrochloric acid. To the fourth add some of the solution of pepsin in water and a few drops of hydrochloric acid. Have the liquids at the same level in all four tubes. Place all four test tubes side by side where they will keep warm but will not be too hot. Examine the contents of the tubes every hour or so during the day and again the following day.

Conclusion. Summarize the results of the experiment by answering in a short paragraph the question in the problem.

Problem 1. Which is more effective in making fat into an emulsion: water, some alkali, such as ammonia, or some acid, such as vinegar or lemon juice?

Materials. Three test tubes; ammonia or lye solution; vinegar or lemon juice; warm water; cottonseed oil, corn oil, or olive oil.

Procedure and observations. Into each of the three test tubes put a half-dozen drops of the oil. To the first add warm water. This test tube is the control. To the second add warm water and a few drops of ammonia. To the third add warm water and a little vinegar or lemon juice. Have equal amounts of liquid in all three test tubes. Allow all three test tubes to stand side by side. Shake the contents of the test tubes from time to time. After two days examine the contents of all three test tubes. Do the contents of any of the test tubes appear milky?

If so, the contents is an emulsion. The milky appearance is due to the breaking up of the fat into very small drops. Save the best emulsion for the second part of the experiment.

Conclusion. Answer in a complete sentence the question asked at the beginning of this experiment.

Problem 2. What is the action of pancreatic juice on emulsified fat, protein, and starch?

Materials. Six test tubes; starch; hard-boiled egg; commercial pancreatin; baking soda; warm water; the emulsion, or emulsified oil, from the preceding experiment.

Procedure and observations. Make some artificial pancreatic juice by adding to 100 cubic centimeters of warm water 1 gram of commercial pancreatin and 2 grams of baking soda. Into each of two test tubes put a small amount of the emulsified oil; into each of two others put a pinch of starch. Into each of two more put a small amount of finely divided white of a hard-boiled egg. To the first test tube of each pair add the pancreatic juice, and to the second tube add warm water for a control. Fill all six test tubes to the same level. Put all six test tubes together in a warm place (70° F to 80° F for two hours). At that time compare the appearance of each pair of test tubes. Summarize the results of your experiment in a few complete sentences.

NAME____________________ DATE____________

GUIDE QUESTIONS FOR STUDY. DIGESTION

[Text pages 343–354]

1. Name in their order, beginning with the mouth, the main divisions of the human alimentary canal, and opposite each name write the functions of the division.

DIVISION	FUNCTIONS
Mouth	*To receive and chew food; to digest starch*

2. In the spaces provided write the names of the digestive glands and the indicated facts about them.

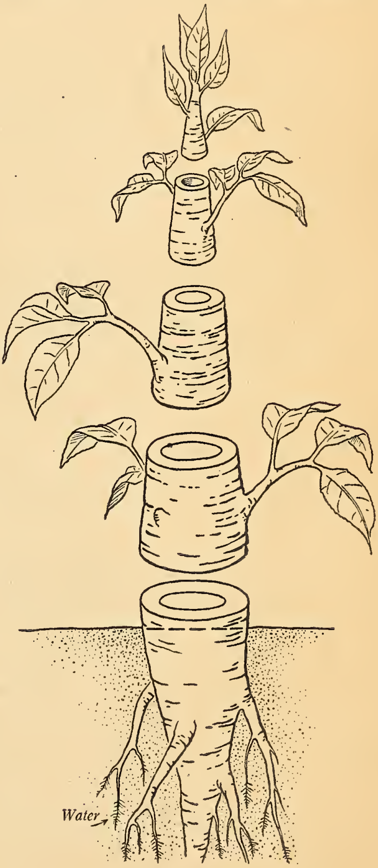
Name of the Gland	Where It Empties Its Secretions into the Alimentary Canal	The Enzymes or Other Secretions it Furnishes	The Function Performed by the Secretion
Salivary	*Mouth*	*Ptyalin*	*Digests starch*

3. Trace the digestion of meat or potatoes, naming the organs through which they pass while being digested and describing the changes that occur.

Self-test on Biological Terms. Be sure you can define these words. Check your definitions with those in the Glossary of your textbook.

alimentary canal
digestion
emulsion
enzyme
esophagus
gastric
membrane
mucous membrane
pancreas
peristalsis
saliva
villus

EXPERIMENT 74. CIRCULATION IN PLANTS



Problem. Do liquids move upward through definite parts of a plant?

Materials. Corn seedling; pea seedling; red ink; sharp knife or razor blade.

Procedure and observations. Place the seedlings in red ink to which an equal amount of water has been added. Remove them the next day. Beginning with the root and proceeding to the top of the plant, cut several cross sections of roots, of stems, and of leaves.

Examine the cut ends for any evidence of colored liquid. In the same way cut and examine a longitudinal section of the stem and of a big leaf vein. What evidence is there that the liquid has circulated upward to the top of the plant?

In the diagram of the entire plant draw arrows to show the path of the liquid upward as you have here observed it.

Exercise on Scientific Method (Making Hypotheses). Cut a willow twig about twelve inches long. Three inches from the cut end make cuts entirely around the stem, and remove a piece of bark about an inch wide. Place the stem in water deep enough to cover the cut. Leave it for a week, or until roots begin to grow. Where do the roots form?

What is the most reasonable explanation you can offer to account for this fact?

NAME____ DATE__________________

EXPERIMENT 75 (OPTIONAL). CIRCULATION IN THE EARTHWORM[1]

Problem. What can one discover concerning the circulation in an earthworm?

Materials. A live earthworm; two microscope slides; a piece of cardboard; two rubber bands; water.

Procedure and observations. Cut a piece of cardboard the same size as the slides. The cardboard should be almost as thick as the worm. In the center of the cardboard cut a slit which is only slightly wider than the worm and about the length of the worm at rest. Place the cardboard on one of the slides, put the worm in the slit, add a drop or two of water, and place the other slide on top as a cover. Put a rubber band around each end to hold all the pieces together.

Look along the back of the worm for evidence of the blood's circulating. Is it flowing toward the anterior end (head) or toward the posterior end of the body?

Near the head find small blood vessels extending down the sides from the upper vessel. These tubes are often called hearts. How many of them can you see? _______ Do they beat more rapidly or less rapidly than your own heart? _______________________________

Turn the entire piece of apparatus over so that you are looking at the ventral side of the worm. You may be able to find here a blood vessel corresponding to the one along the back of the worm.

What color is the blood of the worm? ____________

GUIDE QUESTIONS FOR STUDY. CIRCULATION

[Text pages 355–365]

1. Why do many-celled plants and animals need a circulatory system?

2. Name five materials which a circulatory system may transport.

3. Name the region of the fibrovascular bundle through which the liquids rise and that through which they descend in higher green plants.

4. How does the circulatory system of a higher plant differ from that of a higher animal?

5. What is the difference between an open and a closed vascular system?

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[1] *To the Teacher.* You may prefer to include this experiment as part 3 of Experiment 48 on pages 68–69 of this workbook.

Exercise on a Biological Principle. What evidence can you cite, from the figure on page 364 of the textbook, supporting the biological principle "In general the higher in the scale of life an animal is, the more complex is its structure"?

*EXPERIMENT 76. CIRCULATION IN A CHORDATE, SUCH AS THE FROG[1]

Problem. How do the capillaries of the frog look, and how does the blood pass through the capillaries?

Materials. A live tadpole or a frog[2]; absorbent cotton; ether; water; slide; microscope.

Procedure and observations. Saturate a piece of absorbent cotton with water to which a few drops of ether have been added, and wrap the cotton around a tadpole; or hold a piece of cotton saturated in ether where a frog can breathe the fumes. When the animal has become quiet, place the tail of the tadpole or the web of the frog's foot under the low power of the microscope, and examine it. Find the many-branched capillaries. Find also the larger blood vessels (arteries) from which the capillaries branch, and those (veins) which the capillaries unite to form. Note the blood cells, or corpuscles, passing through the capillaries. Are they moving slowly or rapidly?

_______________ Does the blood move more slowly or more rapidly in the capillaries than in the arteries and the veins?

What is the advantage of this change of speed?

Conclusions. Summarize your observations in a brief paragraph describing what you have learned about circulation in the frog. Supplement your description with a diagram.

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[1] *To the Teacher.* You may prefer to include this experiment as part 6 of Experiment 56 on page 87 of this workbook.

[2] The blood flow may be observed in the fin or tail of a goldfish or minnow if the fish is treated in the same way as the tadpole or if a few drops of ether are placed in the water in which the fish is swimming.

EXPERIMENT 77. CIRCULATION IN MAN

Problem. What can one observe concerning the circulation of the blood in man?

Procedure. Locate on your own body the point where the heart-beat is most distinct. On which side is it?

Count the beats for one minute. Repeat several times, and find the average number of beats per minute. With your finger find the pulse in the artery in your wrist. Count it for several trials, and record the results. Locate the artery in your temples. In the same way count the pulse beats and record the number.

Heart-beat . . Trial 1 -------- Trial 2 -------- Trial 3 -------- Average --------

Pulse at wrist . Trial 1 -------- Trial 2 -------- Trial 3 -------- Average --------

Pulse in temple Trial 1 -------- Trial 2 -------- Trial 3 -------- Average --------

Do you find any relation between the counts of the heart-beat and the pulse?

What does this fact indicate?

Can you detect any pulse in the blue veins close to the skin on the back of your hand? --------
Hold your hand downward and shake it gently. Note the result.

Now hold your hand above your head for a minute. Note the result.

Gently press a vein on the back of your hand at the Y-shaped forks of the veins where valves are located, and on the wrist, rubbing tightly against the flesh toward the fingers. Release the pressure and note the direction in which the blood flows back into the vein. Repeat until you are sure. Is the blood apparently flowing upward or downward in these veins?

What do you infer is the function of the valves?

Exercise on Scientific Method (Inventing Experiments). Plan a series of experiments by which you may determine the effect upon pulse rate of varying conditions, such as excitement, worry, and physical activity. Also, plan experiments by which you may determine whether boys and girls of the same ages have the same pulse rates and whether boys of different ages and girls of different ages have the same pulse rates. Record your experiment steps and data on another sheet.

GUIDE QUESTIONS FOR STUDY. CIRCULATION

[Text pages 365–371]

1. What functions of the arteries would not be served if these blood vessels had walls like the walls of veins?

2. What advantages are derived from the fact that the walls of the capillaries are composed of a single layer of cells?

3. Compare the circulatory system of man with the lymphatic system (see "How to Study," p. x of your textbook).

SIMILARITIES	DIFFERENCES

4. Starting at the left ventricle of the heart, trace the path of the blood completely through the circulatory system and back to the left ventricle.

5. Which artery is filled with blood like that in the veins? ______________________________

Which vein is filled with blood like that in the arteries? ______________________________

6. Which artery is filled with blood having less oxygen and more carbon dioxide than that in other arteries? ______________________________ Which vein is filled with blood containing more oxygen and less carbon dioxide than that in other veins? ______________________________

7. Why is it dangerous to drink alcohol if one is exposed to extreme cold?

EXPERIMENT 78 (OPTIONAL). THE STRUCTURE OF A HEART

Problem. What are some of the structures in a bird's heart or a mammal's heart?

Materials. Heart of a cow, a pig, or a chicken; knife.

Procedure and observations. Note any large blood vessels leading to or from the heart. Cut the heart lengthwise from the top almost to the bottom. How many cavities has it? _______ Where are the walls thickest?

How many of the chambers have large blood vessels connecting with them? _______ Can you discover any valves? _______ If so, where?

At the bottom of the page make a sketch of the structures of the heart as they appear in the section of your specimen.

*EXPERIMENT 79. STUDY OF HUMAN BLOOD

Problem. What structures are found in human blood?

Materials. Slide and cover glass; needle; absorbent cotton; alcohol or other disinfectant; microscope.

Procedure and observations. Moisten a bit of absorbent cotton in alcohol; then rub the alcohol over the end of your finger to kill the germs on the skin. Sterilize a needle by dipping it into alcohol or by holding the tip of the needle in a flame. Squeeze the finger to force the blood to the end; then stick the needle into the finger, and extract a small drop of blood. Put the drop of blood on a slide, and spread it out well. Cover with a cover glass, and examine under low power and then under high power. What is the color of the blood as seen through the microscope?

------------------------ Which parts, if any, are not colored?

Observe any solid bodies in the liquid. These are called corpuscles. Are all the corpuscles alike?

------- In order to answer the last question you may need to examine several samples of blood. In the space below draw sketches of the blood corpuscles.

Conclusions. Complete the following sentence: The human blood is composed of a ------

------ colored liquid and ------------.

GUIDE QUESTIONS FOR STUDY. THE BLOOD

[Text pages 372–379]

1. Where are new red corpuscles made?

2. Where are new white corpuscles made?

3. List the parts or structures of the blood, and state with each its functions.

STRUCTURE	FUNCTION
---*Red corpuscle*-----	---*To carry oxygen and carbon dioxide*------------------------------
------------------	--
------------------	--
------------------	--
------------------	--
------------------	--
------------------	--

4. List the structures labeled in the figure on page 375 of the textbook. Opposite the names write the functions.

STRUCTURE	FUNCTION
Mucous gland	*To secrete mucus, a fluid which moistens the walls of the intestine*

5. What changes occur in the blood as it passes through the parts of the body listed in the chart below?

PART OF BODY	CHANGES IN THE BLOOD
Muscle cell	*Oxygen, food, and hormones taken out of the blood; carbon dioxide, water, and other wastes added to it*
Lungs	
Villi	
Liver	
Brain	

Self-test on Biological Terms. Be sure you can define these words. Check your definitions with those in the Glossary of your textbook.

artery
assimilation
auricle
blood vessel
circulation
circulatory system
corpuscle
heart
lymph
lymph node
lymphatic
lymphatic system
plasma
vein
ventricle

NAME ____ DATE ______________

*EXPERIMENT 80. RESPIRATION IN PLANTS

Problem. Does a green plant, such as a bean plant, give off carbon dioxide as a product of respiration?

Materials. Two large wide-mouthed jars with covers; soil; bean seeds which have begun to sprout; two small dishes; limewater.

Procedure and observations. Put a two-inch layer of soil into each of the two large jars. In one of these jars plant two or three of the bean seeds. Keep both jars in a warm sunny place until the bean plants have developed leaves. Now place in each jar a small dish of limewater. Cover the jars to exclude the air, and place them side by side in a window. From time to time observe the limewater in both jars.

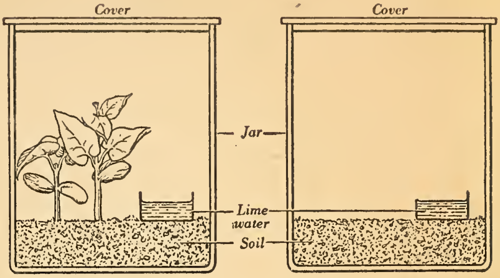


Fig. 1

Conclusion. Indicate the results of this experiment by adding labels to the figure. Also write "Control" on the part of the figure which represents the control, and indicate with another label what is the experimental factor.

EXPERIMENT 81. RESPIRATION OF SEEDS

Problem. Will seeds grow without a supply of oxygen?

Materials. Two small jars or bottles with covers or stoppers; soaked peas or beans.

Procedure and observations. Put six soaked seeds into each jar. Close one jar tightly so that no air can enter. Leave the other jar open, but do not let the seeds dry out. Examine daily for a week.

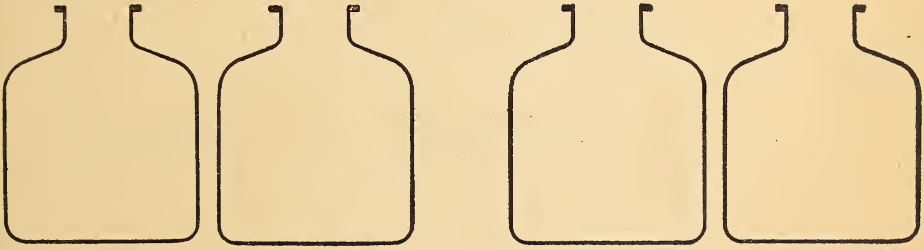


Fig. 2

Conclusions. In which jar did the seeds grow better? Complete the drawings in Fig. 2 to show the jars and seeds at the beginning and at the end of the experiment.

Exercise on Scientific Method

1. Which of the two jars in Experiment 81 was the control? ______________________________
What purpose did it serve?

2. What was the experimental factor in Experiment 81? ______________________________
Explain.

3. Did any of the seeds in the closed jar grow? ____________________________________
How do you explain this?

4. Plan a check experiment similar to this one, except that all the oxygen is removed from the sealed jar. List the steps in the experiment here.

5. Plan an experiment to show whether or not germinating seeds give off carbon dioxide. List the steps in the experiment here.

GUIDE QUESTIONS FOR STUDY. RESPIRATION

[Text pages 380–383]

1. Compare photosynthesis and respiration. (You will need to use the Index of your textbook in reviewing photosynthesis.)

	PHOTOSYNTHESIS	RESPIRATION
Gas used?	______________________	______________________
Gas given off?	______________________	______________________
Occurs in what cells? . . .	______________________	______________________
Time of day when it occurs?	______________________	______________________
Waste products?	______________________	______________________
Energy stored or released? .	______________________	______________________
Food produced or used? . .	______________________	______________________

2. Write in one column the names of the plant phyla. Opposite each name write the names of respiratory structures, if any, which the members of the phylum have.

PHYLUM	RESPIRATORY STRUCTURE
(1) ----------------	--
(2) ----------------	--
(3) ----------------	--
(4) ----------------	--

3. What waste products of respiration in all plants and animals are also produced as waste products whenever fuel burns?

4. What is the distinction between internal respiration and external respiration?

5. What organs in green plants permit air to enter and to leave the plant? --------------

-------------- Where are they located?

EXPERIMENT 82. BREATHING

Problem. What causes air to enter and leave the lungs?

Materials. Bell jar; one-hole rubber stopper; sheet rubber; toy balloon; glass tubing; string; marble.

Procedure and observations. Set up apparatus as in the figure. The balloon represents a lung; the bell jar, the lung cavity; the sheet rubber, the diaphragm. Pull the diaphragm downward to increase the volume of the lung cavity, as when you inhale. Then push it upward, as when you exhale. Observe what happens.

Conclusion. Cross out the incorrect word of each pair in the following sentences:

When the volume of the lung cavity is increased, the (greater · lesser) air pressure (inside · outside) pushes air (into · from) the lungs.

When the volume of the lung cavity is decreased, the (greater · lesser) air pressure (inside · outside) pushes air (into · from) the lungs.

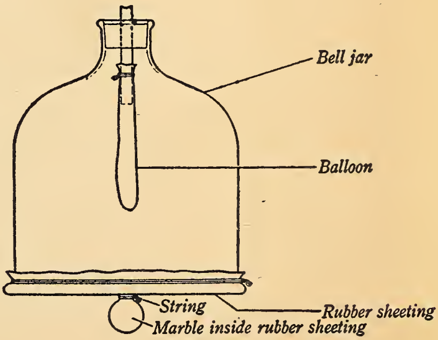


Fig. 3

GUIDE QUESTIONS FOR STUDY. RESPIRATION

[Text pages 383–393]

1. Supply the information required to complete the following chart:

ANIMAL	RESPIRATORY ORGANS	WHERE LOCATED
Amoeba . .		
Sponge . . .		
Starfish . . .		
Clam		
Crayfish . .		
Fish		
Earthworm .		
Grasshopper		
Frog		
Man		

2. Trace the path followed by air from the time it enters the nostrils (in man) until it again leaves the nostrils. State opposite each name the changes, if any, which take place in the air as it passes.

PORTION OF THE RESPIRATORY SYSTEM	CHANGES EFFECTED
Passage in the nose	*Some dust removed; air somewhat warmed*

Self-test on Biological Terms. Be sure you can define these words. Check your definitions with those in the Glossary of your textbook.

diaphragm gill larynx lenticel lung pharynx respiration trachea

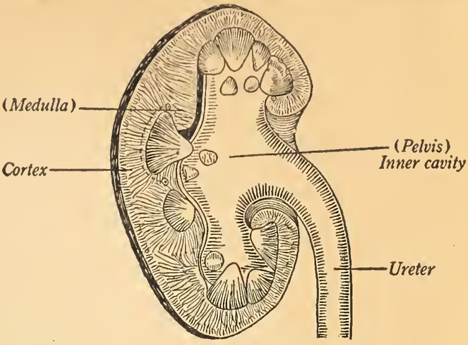
NAME____________________________ DATE________________

EXPERIMENT 83. THE KIDNEY

Problem. What is the structure of the kidney?

Materials. Kidney from a pig, a calf, or a sheep; knife.

Procedure and observations. What is the approximate size of the kidney?



Find the tube (ureter) through which the urine passes from the kidney to the bladder. Cut the kidney into halves, lengthwise. Compare the inside with the figure.

Conclusions. Describe briefly the structure of the kidney, showing how it is adapted to perform its function.

GUIDE QUESTIONS FOR STUDY. EXCRETION

[Text pages 394–398]

1. In what part or parts of living organisms does metabolism take place?

2. What are the waste products of metabolism?

3. Write opposite each kind of organism the means by which it eliminates solid wastes.

(1) *One-celled plants*

(2) *Higher plants*

(3) *Protozoa*

(4) *Simple Metazoa*

(5) *Higher animals*

4. Write opposite the name of each animal the organs of excretion, if any, with which it eliminates urea and other soluble waste substances.

(1) *Amoeba*

(2) *Paramecium*

(3) *Earthworm*

(4) *Bee*

(5) *Clam*

(6) *Fish*

(7) *Dog*

5. What in *Amoeba* or *Paramecium* corresponds to the bladder in higher animals?

6. Why is a vascular system necessary as a means of eliminating the products of metabolism in higher animals but not necessary in simple animals?

GUIDE QUESTIONS FOR STUDY. EXCRETION

[Text pages 398–401]

---

1. List the excretory functions of the liver.

2. What structures of the human body effect chemical changes as a necessary part of the excretory process?

What are these chemical changes?

3. Complete this chart to show the human excretory organs that separate waste products from the blood:

EXCRETORY ORGANS	PRODUCTS
(1) ----------------------	----------------------
(2) ----------------------	----------------------
(3) ----------------------	----------------------
(4) ----------------------	----------------------

4. State the functions of the sweat glands in the skin.

5. Which of the human excretory organs have important functions other than the removal of waste products?

What are these functions?

Self-test on Biological Terms. Be sure you can define these words. Check your definitions with those in the Glossary of your textbook.

bladder excretion kidney metabolism sweat gland urea

NAME____ DATE__________________

GUIDE QUESTIONS FOR STUDY. GLANDS

[Text pages 402–410]

1. What are the types of glands, and how do they differ?

2. To which type of gland should you consider the mucous glands to belong? ______________

______________ Justify your answer.

3. Endocrine glands have thus far been discovered in no kind of animal below the phylum __

______________________.

4. List the important endocrine glands of man, and write opposite the name of each its functions.

NAME OF GLAND	FUNCTIONS
___*Pineal*___________	___*Influences development of brain and of reproductive organs*___________

5. People may become abnormally tall through a failure of the ________________________

gland. People may be abnormally short because of a failure of the ________________________

and the ________________________ glands.

6. Which of the glands in certain lower organisms is a rudimentary third eye?

7. Under great excitement or in times of danger a person can often perform muscular feats which he would ordinarily find impossible to accomplish. Such feats are made possible by hormones secreted by what glands?

8. List the organs which contain both endocrine glands and glands with ducts. Opposite each organ write first the functions of its glands with ducts and then the functions of its endrocine glands.

Organ	Functions of Its Glands with Ducts	Functions of Its Endocrine Glands

9. Which gland produces the hormone that prevents diabetes? ________________________

10. Which gland is defective in an individual who has goiter? __________________________

Self-test on Biological Terms. Be sure you can define these words. Check your definitions with those in the Glossary of your textbook.

duct gland
endocrine gland
gland
hormone
secretion

Exercise on Scientific Attitudes and Scientific Methods. Consult a physiology textbook or an encyclopedia for the story of the discovery of insulin. List the scientific attitudes which Banting and Best evidently possessed. List also the scientific methods that they employed. For the "Scientific Attitudes" and the "Elements of Scientific Method" see pages 624 and 625 of *Everyday Biology*.

NAME____ DATE________________

*EXPERIMENT 84. TROPISMS IN PLANTS

Problem. Does gravity influence the direction in which roots and stems grow?

Materials. Two pieces of glass about five inches square; blotting paper; quarter-inch strips of wood; corn, oat, or radish seeds; gummed tape.

Procedure and observations. Make a "pocket garden" thus: On one of the glass plates place several layers of moist blotting paper. Place around the edges of the plate the wood strips to support the second glass plate. Put in various places on the wet blotting paper several seeds which have soaked for several hours. Cover these with the second plate of glass, and fasten the plates together by putting the gummed tape around the edges. Stand the pocket garden on edge. Keep it moist, but not wet.

In the space below draw a sketch of the pocket garden with the seeds, showing the direction in which the young roots and the young stems grew. You may need more than one sketch to do this.

Turn the garden completely over, standing it on the opposite edge from that on which it first rested. After one day or longer, make further sketches to show the direction in which the roots and the stems now grow.

EXPERIMENT 85 (OPTIONAL). TROPISMS IN ANIMALS

Problem. Do certain animals, such as millepedes, spiders, or beetles, show a positive or a negative tropism toward light?

Materials. Several arachnids or insects or both; flashlight.

Procedure and observations. Place the animals, one by one, in a darkened space. Turn the flashlight upon the animal and watch its reaction.

Answer with one or more complete sentences the question asked in the problem.

Exercise on Scientific Method (Evaluating Conclusions and Inventing Experiments)

1. Should you be justified in concluding from Experiment 85 that all animals of the kinds with which you might experiment would behave toward light as these did? Justify your answer.

2. Can you invent an experiment to determine whether Protozoa, such as *Paramecium* and *Amoeba*, or whether Metazoa, such as *Hydra*, the earthworm, the fruit fly, and the crayfish, exhibit a positive or a negative tropism toward light? If so, state here the steps you would follow in carrying out this experiment.

If possible, secure the animals and perform your experiment. Record here the result.

GUIDE QUESTIONS FOR STUDY. RESPONSES

[Text pages 414–418]

1. Make a sentence using these words: *response*, *organism*, *stimulus*, *reaction.*

2. Make up an original example of irritability.

3. Here is a list of kinds of stimuli: heat, gravity, sunlight, sound, other organisms of various kinds, other organisms like themselves, odors, flavors, water, contact, light in general, decreasing light.

To which of these do all organisms respond?

Do higher plants respond to any to which lower plants do not respond?

Do all plants respond to any to which all animals do not?

Do all animals respond to any to which all plants do not?

Do higher animals respond to any to which lower animals do not?

4. What are the characteristics of a tropism?

Exercise on Biological Principles

1. Give an original example illustrating the principle "Different sorts of living things react to the same stimulus in different ways."

2. Explain and illustrate this principle: "In general, tropisms are an aid to survival."

GUIDE QUESTIONS FOR STUDY. RESPONSES

[Text pages 419–425]

1. Compare a neuron with a muscle cell.

SIMILARITIES	DIFFERENCES

2. Why is an earthworm able to respond to stimuli with more complex reactions than simpler animals?

3. How are tropisms, reflexes, and instincts alike?

How does each differ from the others?

4. A sitting hen which was not permitted to have a nestful of eggs discovered a mother cat and her litter of kittens. The hen insisted upon hovering the kittens whenever the mother cat was away from them. How should you explain this behavior?

5. Give two examples of unlearned responses, preferably some you have observed.

NAME____ DATE________________

GUIDE QUESTIONS FOR STUDY. RESPONSES

[Text pages 425–430]

1. What is the difference in location between the principal nerve cord of an invertebrate and that of a chordate?

2. Explain your reaction if, while in bathing, you should step on a sharp stone. Use these terms: *muscle*, *spinal cord*, *sensory neuron*, *motor neuron*, *end organ*, *reflex arc.*

3. Write after each of the following names of animals the kind of nervous system it possesses:

(1) *Protozoa* ___*No nervous system* ____

(2) *Hydra*

(3) *Starfish*

(4) *Earthworm*

(5) *Insect*

(6) *Frog*

(7) *Man*

4. List the parts of the human nervous system, and opposite each part write its chief functions.

PART	FUNCTION
___*Cerebrum*_______	___*Controls higher thought processes; voluntary activity*_______________
________________	____

PART	FUNCTION

Exercise on a Scientific Principle. Can you state as a principle what the relationship is that exists between the intelligence of an animal and the relative size of its cerebrum ?

GUIDE QUESTIONS FOR STUDY. LEARNED RESPONSES

[Text pages 431–440]

1. What is the distinction between an unlearned and a learned response?

2. Give an original example which illustrates the fact that learning consists in modifying response.

3. State the characteristics of learned responses.

4. Suggest a method by which a dog might be taught to "shake hands."

NAME____ DATE__________________

GUIDE QUESTIONS FOR STUDY. LEARNED RESPONSES

[Text pages 440–450]

1. List in order all the steps necessary in learning to write on a typewriter.

2. What arguments should you give to convince a person that he was wrong when he said he was too old to learn French?

3. What is indicated by the fact that good students are usually good in all their subjects, and are likely to succeed in whatever they undertake?

4. What are some advantages of a long infancy?

Self-test on Biological Terms. Be sure you can define these words. Check your definitions with those in the Glossary of your textbook.

cerebellum
cerebrum
ganglion
instinct
medulla
nerve
neuron
reaction
reflex
response
sense organ
stimulus
tropism
unlearned reaction

PROJECT 22. TO MAKE A MAZE OR A PUZZLE BOX AND FIND HOW LONG IT TAKES AN ANIMAL TO LEARN THE MAZE OR THE BOX

Procedure. Make a maze with a few turns and with a few choices of passages, or make a simple puzzle box the door of which opens only when a string is pulled or when an animal pushes against one certain spot. Put some food at the outside end of the maze or just outside the puzzle box. Put into the maze or the box a cat, a white rat, a chick, or some other animal. Time it to see how long it takes to escape. Watch what sorts of movements it makes before it finally finds its way out. Allow it to eat some of the food; then repeat the experiment. Repeat the experiment several times a day until the animal has learned to escape with no false movements.

Make your record here, and at the bottom of the page draw a diagram of your maze or puzzle box.

NAME____ DATE________________

EXPERIMENT 86 (OPTIONAL). NERVE ENDINGS

Problem. Are there different nerve endings in the skin for the senses of pressure, pain, heat, and cold?

Materials. Ink; a small nail or a wire hairpin.

Procedure and observations. On the skin of your forearm outline with ink a square about the size of the figure. Holding the nail in the other hand, run it lightly and not too rapidly back and forth over the skin marked by the square. Whenever you strike an especially sensitive spot (which is probably an ending of a pain nerve), put a dot in the corresponding spot on the record square.

Heat the nail slightly, so that it is definitely warm. Pass it over the skin in the same way. Mark in your record square the locations of the spots which seem especially sensitive to heat.

Cool the nail, and try to find the endings of the nerves which are sensitive to cold. Mark the locations of these with crosses on the square.

Fig. 1

Locate and mark with a cross inside a circle any spots which you find to be sensitive to the pressure of the nail but which do not give sensations of heat, cold, or pain.

Complete your record by writing here a legend which explains the figure.

EXPERIMENT 87. NERVE ENDINGS

Problem. Are the nerve endings of touch closer together in some parts of the body than in others?

Materials. Two pins or a compass with two points. (Two members of the class will need to work together on this experiment.)

Procedure and observations. Holding the two pins about one fourth of an inch apart, touch the points lightly but firmly to the back of your partner's hand. Can he feel two separate points? Now move the pins closer together. Can he still feel two separate points? Try this several times until you determine the approximate distance at which he can distinguish two separate points. Occasionally use only one pin, to be sure he is not imagining that he can distinguish the points.

How close together do the nerve endings of touch seem to be on the back of his hand? _______
Try the same experiment on other parts of his body, such as the shoulder, the finger tip, the forehead, and so on.

Where are the nerve endings closest together on the parts touched? ____________________

________________ Where farthest apart? ____

Now exchange positions, and have your partner perform the same experiments with you.
Do the results which you obtain agree with those obtained with your partner or differ from them?

Exercise on Scientific Method (Using Controls)

In Experiment 87 how did each of you serve as a control for the other?

EXPERIMENT 88. SENSE OF TASTE

Problem. Can one distinguish such foods as onion, apple, and potato by taste alone?

Procedure and observations. Blindfold a member of the class, and have him hold his nose tightly. Then place upon his tongue a small piece of apple, onion, or potato. Can he tell which it is? _______

Try the same experiment with maple sirup, cane-sugar sirup, and sugar sirup flavored with vanilla extract.

Conclusion. Is it the difference in taste or in smell that allows us to distinguish such things?

GUIDE QUESTIONS FOR STUDY. SENSE ORGANS

[Text pages 451–456]

1. How do you explain the fact that simple animals respond to fewer kinds of stimuli than do higher animals?

2. What advantage does an animal like the dog derive from having several important sense organs located on the head?

3. Write after the name of each animal in the following chart the sense or senses upon which it depends chiefly for (1) food-getting and (2) protection:

ANIMAL	FOOD-GETTING	PROTECTION
Earthworm .	________________	________________
Crayfish . .	________________	________________
Bee	________________	________________
Fish	________________	________________
Frog	________________	________________
Bird	________________	________________
Dog	________________	________________

EXPERIMENT 89. STRUCTURE OF THE EYE

Problem. What are some of the structures of the eye?

Materials. Two or three fresh eyes from cows or pigs (preferably from cows because the eyes are larger); sharp-pointed (dissecting) scissors.

Procedure and observations. With the scissors cut off the eyelids so that you have only the eyeball. Find the optic nerve. (Note its location in the figure.) What color is it? _______ Insert the point of the scissors into the back of the eyeball just above the optic nerve. Is the outer coat of the eye easily pierced? __________________ What advantage is there in having the coat of the eye like this?

Cut out the optic nerve so as to leave a small opening in the back of the eyeball. Try to keep the jelly-like liquid inside the eyeball from escaping. Now hold the eyeball so that you can look toward the front of the eye through the opening you have cut. By moving your head slightly you will be able to see, through the eye, the image of objects in front of the eyeball. (You may have to try this with more than one eyeball before you succeed.)

This image you see is the same sort of image which the cow or the pig saw with the eye. Is it right side up or is it upside down? _________________________
Make the opening in the back of the eyeball larger, and allow some of the liquid to escape. Is it transparent, translucent, or opaque? _________________________
Examine the inside coating at the back of the eye. This is the retina. What is its color? ____________ Carefully remove the jelly-like liquid until you discover the lens. The figure shows its shape when you look at it from the edge. Draw a small diagram to show the shape of the lens as you look at it from the front.

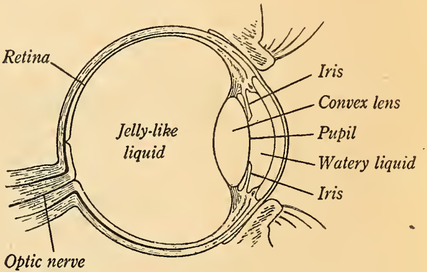


Fig. 2

Exercise on Scientific Attitudes. List the scientific attitudes (pages 624–625 of *Everyday Biology*) which you think an observer would need to possess in interpreting the responses of animals to various stimuli.

Exercise on a Biological Principle. Cite evidence in support of this biological principle: "The senses are important aids to survival."

PROJECT 23. TO EXAMINE THE EYES OF VARIOUS KINDS OF INSECTS AND ARACHNIDS

Procedure. With a hand lens examine the heads of various insects, such as flies, moths, and ants, and of various kinds of spiders, a millepede, a sow bug, a pill bug, a centipede, and the like. Make sketches of the fronts of their heads, showing the locations of the compound and simple eyes.

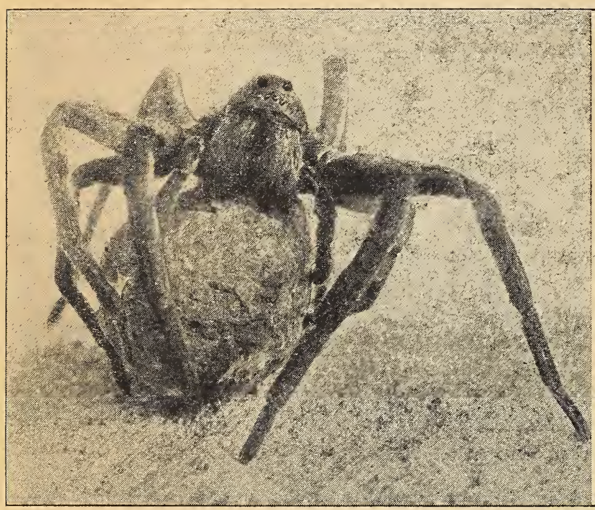


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Fig. 3

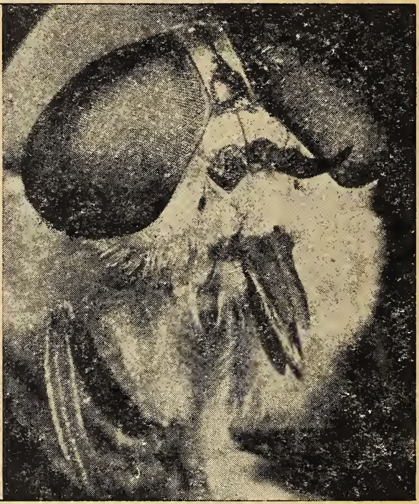

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Fig. 4

Remove a small piece from the compound eye of a fly or other insect. Mount it on a slide, and study it first under the low power of a microscope and then under the high power. Make a sketch showing the shape of the separate parts (facets). Make slides of eyes of other insects and of arachnids, and show by sketches whether they are alike or different from one another.

GUIDE QUESTIONS FOR STUDY. SENSE ORGANS

[Text pages 456–467]

1. Complete the following chart, showing increasing complexity of light-receiving structures:

Structures	An Animal Possessing These Structures	Extent to Which These Structures Function
Scattered nerve ends	*Earthworm*	*Sensitive to the stimulus of light*
Simple eyespots		
Simple eyes		
Compound eyes		
Lens type		

2. What are the advantages of having two eyes rather than one?

3. List the essential structures of the human eye, and opposite each write its functions.

STRUCTURE	FUNCTIONS

4. How should you explain this statement: "We see with our brains rather than with our eyes"?

5. If a dog and a grasshopper had only their heads under water, which would be likely to hear more clearly the sound of stones tapped together under water? ______________________________
Explain.

6. List the essential structures of the human ear, and opposite each write its functions.

STRUCTURE	FUNCTIONS

7. How should you explain this statement: "We hear with our brains rather than with our ears"?

Self-test on Biological Terms. Be sure you can define these words. Check your definitions with those in the Glossary of your textbook.

- auditory nerve
- compound eye
- iris
- lens
- optic nerve
- pupil
- retina
- sensation
- sense organ
- simple eye

NAME______________________________ DATE__________________

EXPERIMENT 90. BACTERIA IN MILK

Problem. Which of several samples of milk from different sources contains the greatest number of bacteria?

Materials. Agar-agar or gelatin culture medium[1]; six clean Petri dishes with covers; samples of milk, including if possible one of pasteurized milk, one of "loose" (bulk, or unbottled) raw milk, one of Grade A raw milk, and one of certified milk; pipette.

Procedure and observations. Pour some of the culture medium into each of the Petri dishes. Make a mixture of 1 cubic centimeter of milk from one of the sources and 99 cubic centimeters of boiled water. Pour this mixture into one of the Petri dishes, and pour off and throw away all excess liquid. Cover the dish. Similarly make a culture from each of the remaining samples. Prepare control *A* by boiling some of the milk for twenty minutes and then adding to one of the Petri dishes 1 cubic centimeter of this boiled milk and 99 cubic centimeters of the boiled water. For another control, *B*, keep one of the Petri dishes containing culture unopened. Put all the Petri dishes together in a warm dark place.

Examine them from day to day to note whether bacterial or mold colonies are growing in the cultures. After a few days count the cultures in each dish, multiply each number by 100, and record below.

SAMPLE	NUMBER OF COLONIES			
	First Day	Third Day	Fifth Day	Seventh Day
1. ___*Pasteurized*_____	______________	______________	______________	______________
2. ________________	______________	______________	______________	______________
3. ________________	______________	______________	______________	______________
4. ________________	______________	______________	______________	______________
5. Control *A*	______________	______________	______________	______________
6. Control *B*	______________	______________	______________	______________

Conclusion. List in order of greatest number of colonies to smallest number of colonies the samples of milk you studied.

---

[1] See "Procedure and observations" of Experiment 36, p. 51, of this workbook for directions for making a culture medium.

EXPERIMENT 91. KOCH'S METHOD

Problem. Can I make a pure culture of bacteria and by inoculating a healthy organism with the bacteria produce the original disease in the organism?

Materials. A rotten potato or a rotten apple; a healthy apple or a healthy potato; two Petri dishes with agar-agar or gelatin cultures (see Experiment 36, p. 51 in this workbook); large steel needle; alcohol; absorbent cotton; wax paper; bell jar or large fruit jar.

Procedure and observations. Read on page 490 of *Everyday Biology* the account of Robert Koch's work, noting especially the four steps by which he proved whether a certain germ caused a certain disease. You will now carry out these four steps with the apples or the potatoes.

Step I. (To secure an organism which is not found in normal tissues.) Secure an apple or a potato that is partly or wholly rotten.

Step II. (To try to make a pure culture of the organism that causes the disease, which in this case is the rotting of the apple or the potato.) First sterilize the surface of the diseased portion of the apple or potato by rubbing over it absorbent cotton which has been saturated with alcohol. Sterilize the needle by heating it red-hot in a flame and then allowing it to cool. Thrust the sterilized needle into the diseased portion of the apple or potato, and drag the needle across the culture in one of the Petri dishes. Repeat several times. Put both dishes side by side in a warm, dark place for several days.

Step III. (To introduce some germs from the pure culture into a healthy organism.) Sterilize the needle as before. Then sterilize the skin of the healthy apple or potato by washing it with alcohol. Transfer with the needle point some of the bacteria from the colonies on the plate. If there are several colonies of different colors on the plate, inoculate the apple or the potato in the same way but in different places with some of the material from each colony.

Why did you sterilize the surface of the apple or potato each time before sticking the needle into it?

Step IV. (To examine the inoculated organism to see whether the disease develops. If it does, you know that the suspected disease-producing germ is in the organism.) Put the apple or the potato in the jar so that you can observe it from day to day without handling it.

Conclusions. Write a brief paragraph describing the results of the experiment.

GUIDE QUESTIONS FOR STUDY. DISEASE PREVENTION

[Text pages 470–481]

1. List kinds of simple organisms which cause disease.

2. Complete the following outline:

I. Diseases of two kinds

A. Communicable, such as ____

B.

II. How communicable diseases are spread by people

III. How communicable diseases are spread by animals

IV. How communicable diseases are spread through water

V. How communicable diseases are spread through food

3. Why are children of tubercular parents liable to contract the disease?

4. In what three ways do germs of most communicable diseases enter the body?

5. State ways in which we may prevent the entrance of disease germs into the body. Be prepared to discuss these in class.

GUIDE QUESTIONS FOR STUDY. IMMUNITY

[Text pages 482–490]

1. Complete the following outline:

I. Natural immunity
  A. Meaning?

  B. Due to
    1. Body structures or to secretions, such as

    2. Individual characteristics, such as
      (1) ---*Kind of animal*---------------- (4) --------------------------------
      (2) -------------------------------- (5) --------------------------------
      (3) -------------------------------- (6) --------------------------------

II. Acquired immunity
  A. Meaning?

  B. Due to
    1.

    2.
      (1)---*With toxins*--
      (2)
      (3)

2. To ward off disease one should secure

One should avoid

3. Why is one unlikely to contract certain diseases, such as whooping cough, twice?

4. What scientific arguments could you offer to convince a mother that she should not intentionally expose her children to any communicable disease?

Self-test on Biological Terms. Be sure you can define these words. Check your definitions with those in the Glossary of your textbook.

antitoxin
communicable disease
disinfectant
germicide
immunity
inoculation
microorganism
toxin

PROJECT 24. TO MAKE A HISTORY CHART OF SOME DANGEROUS DISEASE

Procedure. Find in an encyclopedia or other reference book the important historical facts concerning the disease and the progress thus far made in the fight against it. Arrange these data vertically in columns, or arrange the facts in their proper order in the same general manner as that which is illustrated in the figure on page 499 of *Everyday Biology*, with or without the little illustrative drawings. Draw or mount your chart on cardboard to become a part of the permanent materials of the biology room.

NAME____ DATE__________________

GUIDE QUESTIONS FOR STUDY. DISEASE CONTROL

[Text pages 492–509]

1. Name six or more serious diseases which man has learned, at least partly, to control.

2. Which of these diseases have been successfully combated by means of inoculations?

By means of eliminating animal carriers?

By means of rest, good food, and the like?

3. Name a disease which is combated by each of the methods of inoculation named on page 502 of the textbook.

4. List the means by which science is steadily decreasing the numbers of victims of disease.

5. State the differences in the ways in which a toxin and an antitoxin aid the body in overcoming a disease.

6. Would a doctor vaccinate a person before or after he became sick with a disease? ___________________ Why?

7. Name two or more diseases which are caused by Protozoa.

8. In what ways does the malarial parasite injure the body?

9. Should you fear to be around a patient suffering with malaria or yellow fever? _______ Why?

10. What is the most effective means of fighting malaria and yellow fever?

PROJECT 25. TO MAKE A "TELEFACTS" GRAPH SHOWING THE CONDITIONS WITH RESPECT TO SOME DANGEROUS DISEASE IN YOUR STATE

Materials. Health reports from your city or your state health department.

Procedure and observations. Make a study of a disease, such as diphtheria, smallpox, tuberculosis, or one of the so-called "children's diseases"—scarlet fever, measles, or whooping cough. In the space below represent the facts which you find by "telefacts" graphs, such as those on pages 483, 494, and 500 of *Everyday Biology.*

Conclusions. State in complete sentences below the graph the facts which the graph reveals, such as whether the disease has been on the increase or the decrease over a period of years, or whether the people of any special ages are more likely to take the disease or to die than those of other ages. If you can find in the reports any facts which might account for the rise or fall of the disease,—for example, the introduction of compulsory inoculation or earlier diagnosis,—state these facts in complete sentences following your conclusions.

NAME______________________________________ DATE_________________

GUIDE QUESTIONS FOR STUDY. HEALTH HABITS

[Text pages 510–515]

1. What habits promote good digestion?

2. What are possible dangers from food fads?

3. List harmful effects of alcohol upon digestion.

4. List harmful effects of tobacco upon digestion.

PROJECT 26. TO MAKE A STUDY OF THE TRUTH OF CLAIMS MADE FOR WIDELY ADVERTISED PATENT MEDICINES

Procedure. Because there are so many different patent medicines, it would probably be best for individual members of the class to make as complete a study as possible of the remedies which are offered for certain diseases and other abnormal conditions—for example, the remedies for headache, cancer, coughing, deafness, and the like. First search through the daily papers and the cheaper class of magazines for advertisements of the type of patent medicine you wish to study. Clip these advertisements for mounting later as an exhibit. Write to the American Medical Association, 535 North Dearborn Street, Chicago, or to the Canadian Medical Association, 184 College Street, Toronto, Ontario, for information concerning the claims and the values of the patent medicines of the kind you are studying. Prepare a ten-minute report on the results of your study of patent medicines to be given before your class or in the school assembly.

A convenient way of assembling your materials is to paste upon a large sheet of cardboard a typical example, or perhaps more than one example, of the advertisement of each remedy which you have found in newspapers or magazines, and which is also discussed in the materials from the American Medical Association or the Canadian Medical Association. Under each advertisement write or print the important information which you have found about the medicine. When you have filled your cardboard with this material, it will be a valuable exhibit for your class or your school bulletin board, and will be gladly accepted by your biology teacher as part of her permanent equipment or materials.

PROJECT 27. TO ILLUSTRATE SOCIAL IMPLICATIONS AND SCIENTIFIC ATTITUDES WITH ADVERTISEMENTS OF PATENT MEDICINES

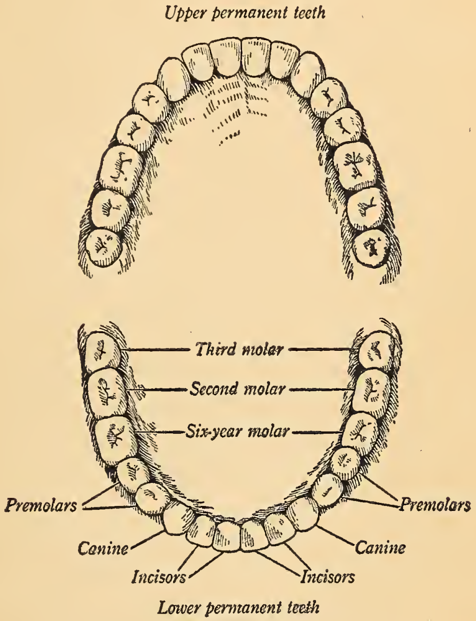
Procedure. Secure information concerning patent medicines and nostrums from the American Medical Association and the Canadian Medical Association as directed in the "Procedure" of Project 26. Mount the picture of each bottle or package, or a sketch of it which you yourself make, on a large sheet of cardboard. Write or print beside each picture the scientific attitude or attitudes that apply to it (see "Scientific Attitudes" on pages 624–625 of *Everyday Biology*). Also, write beside each picture a sentence or a short paragraph giving the social implications of the picture. The completed cardboard will make a prized exhibit for your class or your school bulletin board, and will be a valuable addition to the permanent equipment of the biology room.

EXPERIMENT 92. THE TEETH

Problem. How nearly a complete set of teeth do you possess?

Materials. Small mirror.

Procedure. Using the mirror, examine your own teeth. Shade on the diagram each of your teeth, leaving blank those which have not yet appeared or which you have lost.



GUIDE QUESTIONS FOR STUDY. THE TEETH

[Text pages 515–518]

1. Make up some rules for the care of the teeth.

2. List several arguments in favor of early dental care.

GUIDE QUESTIONS FOR STUDY. HYGIENE OF RESPIRATION

[Text pages 518–526]

1. Why do training rules for athletes prohibit smoking?

2. What are the functions of ventilation?

(1) --

(2) --

(3) --

Draw a circle around the number in front of the most important of these functions.

GUIDE QUESTIONS FOR STUDY. ACCIDENT PREVENTION

[Text pages 526–528]

1. List several ways of preventing accidents in the home.

2. Why is it essential in artificial respiration to keep the motions slow, smooth, and regular?

3. List what should be done in cases of fainting, small cuts, and bruises.

GUIDE QUESTIONS FOR STUDY. SAFEGUARDS OF HEALTH

[Text pages 528–535]

1. What public services protect the health of the people of your community?

2. State reasons why the use of food adulterants should be prohibited.

3. Why is it safer for a person to follow a prescription given by a physician than to take a patent medicine advertised as a remedy for a disease he thinks he has?

4. List the six rules of hygiene which you consider most important of all those discussed in this chapter.

5. Can you suggest a law which you think necessary as one means of reducing the number of drug addicts?

Self-diagnosis (Mental Health). The following list of questions is based on the section "Mental health" in *Everyday Biology*, pp. 535–539. Make a careful and honest answer to each of the questions by putting a check on the line under the heading ("Never," "Seldom," etc.) which represents your estimate of yourself with respect to that trait or mental habit. Then make a "profile" by drawing a line which connects all the check marks you have made on the various lines.

	Never	Seldom	About as Often as Not	More Often than Not	Always
Do you get enough sleep?					
Do you plan your time so that you get things done when you should?					
Do you try to decide questions without help from others?					
Are you a cheerful person?					
Do you take into account your own good points?					
Do you try to strengthen your weak points?					
Do you try to strengthen your strong points?					
Do you try to do well whatever you do?					
Can you lose gracefully?					
Are you willing to try again if you fail?					
Are you friendly to others?					
Can you work with others without friction?					
Have you confidence in yourself?					
Do you like to be with other people?					
Do you cultivate a hobby?					
Do you try to face unpleasant situations and make the best of them?					

NAME--- DATE-----------------

PROJECT 28. TO ILLUSTRATE SOCIAL IMPLICATIONS AND SCIENTIFIC ATTITUDES WITH CARTOONS

Procedure. Collect from newspapers and magazines cartoons which you think illustrate scientific attitudes or point out social implications or do both; or draw a cartoon or a series of cartoons of your own. Mount the cartoons on large sheets of cardboard. Write or print beside each the scientific attitude or attitudes which apply to it (see "Scientific Attitudes" on pages 624–625 of *Everyday Biology*). Or write beside each picture a sentence or a short paragraph stating the social implications of the picture. Or write beside each both the scientific attitudes and the social implications. Usually if a cartoon illustrates a scientific attitude, it also points out social implications. The completed cardboard will make a valuable exhibit for your class or your school bulletin board, and will be a prized addition to the permanent equipment of the biology room.

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PROJECT 29.[1] TO MAKE A "TELEFACTS" GRAPH INDICATING SOCIAL IMPLICATIONS OF ACCIDENTS

Procedure. Secure from local agents for accident-insurance companies facts relative to the numbers of automobile accidents, accidents in the home, and the like, for a certain year or for a longer period. Perhaps you will wish to separate the fatal accidents from the nonfatal ones. Make a "telefacts" graph similar to those on pages 483, 530, and 534 of *Everyday Biology*. State in a few sentences below your graph the most important facts and social implications which the graph shows.

---

[1] *To the Teacher.* This project is especially valuable as a group activity in which various committees or groups of students prepare "telefacts" graphs.

NAME____ DATE__________________

GUIDE QUESTIONS FOR STUDY. THE HISTORY OF THE THEORY OF SPONTANEOUS GENERATION

[Text pages 542–547]

1. Give an example of spontaneous generation.

2. From the list of principles on pages 626–627 of *Everyday Biology* select the one that scientists accept instead of the theory of spontaneous generation.

3. State the contributions to the establishment of the theory now held which were made by

REDI

PASTEUR

TYNDALL

*EXPERIMENT 93. BUDDING OF YEAST

Problem. How do yeast plants look, and how do they reproduce?

Materials. Part of a yeast cake; test tube or flask; sugar; compound microscope; slide and cover glass.

Procedure and observations. Put into the test tube a piece of the yeast cake the size of the end of your finger, add about a teaspoonful of sugar, and shake the test tube until the sugar has dissolved and the yeast cake has been broken up.

By the next day the yeast will have multiplied sufficiently so that it can easily be studied. Put a drop of the liquid in the test tube on a slide, and place the cover glass over it. Study the drop first under the low-power and then under the high-power objective. Make sketches of any large cells with smaller cells attached to them which you observe. These smaller cells are the buds.

EXPERIMENT 94 (OPTIONAL). BUDDING OF *HYDRA*

Problem. How does *Hydra* reproduce by budding?

Materials. *Hydra* culture; magnifying glass.

Procedure and observations. Examine the culture carefully until you find a hydra which is in the process of budding. If you find such a specimen, sketch it.

EXPERIMENT 95 (OPTIONAL). REGENERATION OF FLATWORMS

Problem. How do flatworms regenerate vegetatively?

Materials. Living flatworms (*Planaria*); very sharp knife; magnifying glass.

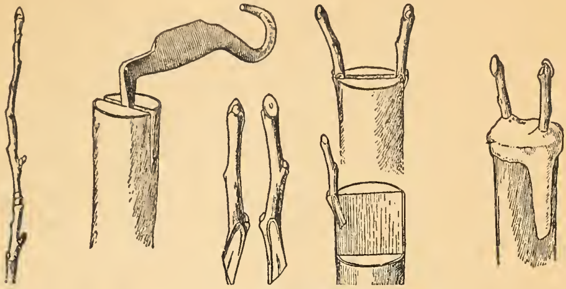
Procedure. Split several flatworms lengthwise completely with a clean cut; do not "haggle." Split several specimens in two pieces crosswise. Return all the specimens, for observation, to a vessel containing water. After two days add bits of liver as food for the animals. Observe the flatworms day by day, recording the development by means of "motion-picture" sketches each of which shows the stage of development for a certain day. Record the date under each sketch.

PROJECT 30. TO MAKE GRAFTS

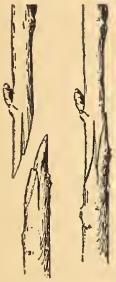
Materials. Very sharp knife; thread or bands of cloth; grafting wax.

Procedure. 1. *The whip graft.* Before attempting to make a whip graft with trees it is well to practice grafting with twigs. Select two twigs of about the same size, one to serve as the stem upon which the graft is to be made, the other to serve as the scion, or twig to be grafted upon the stem. Cut off each with a clean slanting stroke, as indicated in the figure, and split each twig near the middle. Be careful not to split too deeply. Slide the two ends together. Wrap them tightly around with thread or cloth. If you were grafting trees, you would use thread which had been dipped in grafting wax and would cover the whole wound with grafting wax.

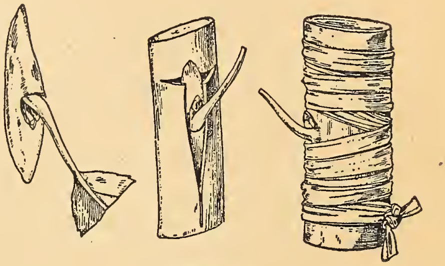
2. *Other methods of grafting.* Use the figure as a guide in making other types of grafts.



A. Cleft grafting



B. Whip grafting



C. Budding

GUIDE QUESTIONS FOR STUDY. ASEXUAL REPRODUCTION

[Text pages 548–562]

1. Name four methods of reproduction without sex.

(1) ------------------------------------ (3) ------------------------------------

(2) ------------------------------------ (4) ------------------------------------

2. An amoeba or a bacterium may be said to be less than an hour old, and yet with equal truth it may be said to be millions of years old. Explain.

3. Name several organisms which may reproduce by more than one asexual method. State the methods used by each organism.

4. Certain bacteria are able to form spores when the liquid in which they are living is heated, with the result that even boiling for a short time does not kill them. When the liquid again becomes cool, they resume life as before. Do such changes into and out of the spore stage illustrate reproduction by spore formation? ------- Explain.

5. Compare reproduction by fission and by budding.

SIMILARITIES	DIFFERENCES

6. Compare reproduction of Protozoa by fission and by the formation of asexual spores (see "How to Study," p. x of *Everyday Biology*).

SIMILARITIES	DIFFERENCES

7. If an amoeba is cut completely in two, each piece will develop into a complete animal. What name is given this method of reproduction?

How does it differ from fission?

8. If you were to find a crayfish with one claw much smaller than the other, what should you infer?

9. In grafting plants what tissues of the fibrovascular bundles of the scion and of the stem must make contact in order that the scion can grow on the new stalk?

10. What is the chief advantage of grafting from the point of view of a fruit-grower?

Self-test on Biological Terms. Be sure you can define these words. Check your definitions with those in the Glossary of your textbook.

asexual reproduction
budding
fission
grafting
regeneration
reproduction
sexual reproduction
spontaneous generation
spore
vegetative reproduction

Exercise on a Biological Principle. What evidence can you give in support of this biological principle: "In general, the higher the organism in the scale of life, the less are its possibilities for regeneration"?

EXPERIMENT 96. REPRODUCTION BY CONJUGATION

Problem. What are the phases of conjugation in *Spirogyra*?

Materials. Fresh or preserved specimens of *Spirogyra*; compound microscope; slides and cover glasses; glycerin for mounting the preserved specimens, or water for mounting the living specimens, or prepared slides showing conjugation of *Spirogyra*.

Procedure and observations. Make a careful study of *Spirogyra* under the microscope to see whether you can discover the stages of conjugation illustrated in the figure on page 564 of *Everyday Biology*. See whether you can find stages in conjugation which appear to be different from those illustrated. Sketch any such stages which you may be able to find. Do you find any examples of conjugation between cells in one filament and cells in two other filaments. If so, sketch what you observe. Do you find any instances of conjugation of adjoining cells in the same filament? If so, sketch them in the space below.

Can you find evidence to enable you to determine whether the cell materials pass always from the same filament to the other filament, or whether the spores may be formed in either filament?

ALTERNATIVE EXPERIMENT 96. REPRODUCTION BY CONJUGATION

Problem. What are the phases of conjugation in *Paramecium*?

Materials. Prepared slides showing conjugation of *Paramecium*; compound microscope.

Procedure and observations. Examine the slides carefully to see whether you can find the stages represented in the figure on page 565 of *Everyday Biology*. You will doubtless find other stages. If so, sketch these.

Name ______________________________ Date ______________

GUIDE QUESTIONS FOR STUDY. REPRODUCTION

[Text pages 563–565]

1. How do sex cells differ from asexual spores?

2. Contrast reproduction of *Spirogyra* asexually by fission with reproduction of *Spirogyra* sexually by conjugation.

(1)

(2)

(3)

3. If a single paramecium were transferred to a favorable new habitat where there were no other paramecia, there would in time be millions of paramecia there. But if a single earthworm were similarly transferred to a favorable habitat where there were no other earthworms, in a relatively short time there would be no earthworms there. Explain.

4. Compare conjugation of *Spirogyra* with that of *Paramecium*.

SIMILARITIES	DIFFERENCES

EXPERIMENT 97. POLLEN

Problem. What are the characteristics of different varieties of pollen?

Materials. Compound microscope; slides and cover glasses; flowers of various kinds.

Procedure and observations. Make slides of the pollen by dusting some of it into a drop of water in the microscope slide. Place the cover glass over the pollen. Examine the specimens first under the low-power and then under the high-power objective. Make drawings of characteristic pollen grains of each different kind which you are studying. Label each kind.

PROJECT 31. TO STUDY POLLINATION

Materials. Several blossoms of each of a number of flowering plants, such as butter-and-eggs, nasturtium, tulip, daffodil, violet, honeysuckle, and any other kinds of flowers except the Compositae, such as the dandelion, sunflower, and cornflower; magnifying glass or a microscope; dissecting needle or a pin; slides and cover glasses.

Procedure and observations. Examine several flowers of the same kind. Note the positions of the stamens and the pistil. In some of the smaller flowers, such as the violet, the stamens are at first difficult to find because they are directly against the base of the slender pistil and seem to be a part of it; you can separate them readily with the dissecting needle or the pin. After you have completed your observations, record your facts in the chart. Are the stamens and pistil of the same length? If not, which is longer, a stamen or the pistil? In the same way examine several flowers of each of the other kinds you have collected for study.

With the magnifying glass examine the anthers of the stamens and the stigmas of the pistils of several flowers which are in different stages of development. Do you find any anthers which are split open and which are discharging pollen? Do the anthers open inside and toward the pistil or outside and away from it? Do you find some or all of the stigmas with glistening surfaces? Those with glistening surfaces are mature and ready to receive the pollen. Do you find in the same flowers ripe stamens giving off pollen and mature pistils ready to receive it? Do you find any flowers of such a form as to make it impossible for the pollen to fall upon the stigma of the same flower?

Select the flowers which have petals of unequal length, such as the nasturtium and the butter-and-eggs. Hold the flowers in their natural positions, and note the positions of the stamens and the pistil. Now thrust your pencil point against the bottom petals to represent as nearly as possible an insect entering the flower. Do the positions of the stamens and the pistils change? If so, can you see any purpose served by this change?

Write beside the name of each flower which you have studied the number—1, 2, 3, 4, or 5—which indicates the one of the methods of cross-pollination which that plant illustrates. (See *Everyday Biology*, p. 569.)

Watch bees, butterflies, and other insects as they go from flower to flower. Does the same kind of insect visit different kinds of flowers in turn or different blossoms of the same kind?

Of what advantage to the flowering plant is this habit of the insects which visit its flowers?

Name of Flower	Stamens Longer than Pistil	Stamens Shorter than Pistil	Stamens Ripen before Pistil Ripens	Tips of Stamens Open Outside	Shape of Flower Prevents Self-pollination

GUIDE QUESTIONS FOR STUDY. POLLINATION

[Text pages 566–570]

State in order the stages from pollination to the development of the embryo in flowering plants.

PROJECT 32. TO POLLINATE A FLOWER ARTIFICIALLY

Materials. Plants in bloom; paper bag; string; magnifying glass; forceps.

Procedure. This method is used to cross two varieties of flowering plants and to make certain that the flowers are pollinated by no other plant except the one with which you wish the cross to be made. Before the flowers open from the bud state, tie over each one a small paper bag. Remove the bags each day long enough to examine the stamens and the pistils with your magnifying glass to determine when these organs are mature. Replace the bags carefully after each examination. As soon as the flower which is to produce the seeds opens, remove the stamens, so that the flower cannot be self-pollinated. When you have found a stigma of one flower and the anthers of a flower of the other variety with which you wish to cross the first flower (provided both are ripe at the same time), remove the bag from each long enough to dust the pollen from the one on the stigma of the other; then cover the pollinated flower again. Do this with a number of blooms on each plant. Do not remove the bag from any of the blooms which you have pollinated until the blooms have entirely withered and have dropped off. There will then be no danger that insects or the wind or any other agency can bring to your pollinated flower any other pollen which can pollinate it.

Save the seeds for planting next season. These seeds are all hybrids from the two species of the same plant.

PROJECT 33. TO STUDY THE MATURING OF SEEDS

Materials. A considerable number of specimens of several kinds of plants which are in flower—for example, the dandelion, thistle, plantain, and other weeds.

Procedure. From some of your specimens pull off separate buds and separate flowers, leaving little or no stem. From other specimens cut off the roots, but leave the stems with all their leaves, buds, and flowers. From still others remove everything except the bare stems, the buds, and the flowers. You should have several specimens, representing each variation from buds and flowers with no stems or leaves whatever to buds and flowers with all the rest of the original plants except the roots. Put all the specimens side by side on the grass in some place where they will not dry out too rapidly. Observe them during the next several days.

Do the flowers of any of the specimens continue to develop and ripen their seeds? ------- If so, which ones?

Do any of the buds? ------- If so, which ones?

Do the flowers and buds without stems behave in any way different with respect to maturing their seeds from the flowers and buds on the stalks with leaves? ------- If so, which ones?

Exercise on the Scientific Attitudes. What was the purpose of taking a large number of plants of several kinds?

Can you support your answer with one of the scientific attitudes listed on pages 624–625 of *Everyday Biology*?

PROJECT 34. SEED DISTRIBUTION

Procedure. Collect seeds of many kinds, especially weed seeds. Examine them, and record in the chart the facts you discover. Sketch in the space below the chart several of the seeds, showing their special adaptations, such as hooks and wings.

Name (If You Know It)	Agent of Distribution	Adaptation, Such as Hooks, Wings, etc.
Maple	*Wind*	*Wings*

EXPERIMENT 98. SOME ASPECTS OF REPRODUCTION IN FLOWERS

Problem. What are some of the different arrangements of ovules and placentas in the seed pods of plants?

Materials. Magnifying lens; ovaries of various flowering plants; a sharp knife or razor blade.

Procedure and observations. Cut one of the ovaries longitudinally and another of the same kind horizontally. Note the arrangement of the ovules and how they are attached to the ovary. Make sketches of both sections, as in the figure. Write under your sketches the name of the plant. Similarly make sketches of the arrangements of seeds of the other kinds of plants you are studying.

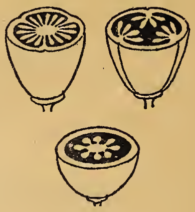


Fig. 1

PROJECT 35. TO STUDY THE DEVELOPMENT OF THE EMBRYO OF A CHICKEN

Materials. Small incubator[1]; fifteen or twenty eggs guaranteed to be fertile; short-bladed dissecting scissors; dish.

Procedure. The eggs must be turned every day; and for about eight days before hatching they must also be sprinkled lightly with water. Open one egg on each day indicated in the time chart, to observe the development of the chick within. It is best not to break the egg for the first five days; instead thrust the points of the scissors through the shell and cut a round hole about the size of a quarter-dollar. Record the developments which you observe. Describe the appearance of the developing embryo from the first day, when you will see the embryo chick as a small red spot, when later you can see the tiny heart beating, when still later you will observe the budding of the limbs, and so on. It will be possible to keep the embryo alive for some time by breaking the egg into a physiological salt solution made by adding 7 or 8 grams of salt to a liter of water kept at about 98° F.

---

[1] A sitting hen with as many eggs as she can hover will serve as an admirable substitute for the incubator.

TIME CHART

Day of Incubation	Observed Development of Embryo	Day of Incubation	Observed Development of Embryo
First		Eighth	
Second		Tenth	
Third		Twelfth	
Fourth		Fourteenth	
Fifth		Seventeenth	
Sixth		Nineteenth	
Seventh		Twenty-first	

ALTERNATIVE PROJECT 35. TO PREPARE AN EXHIBIT SHOWING THE DAY-TO-DAY STAGES IN THE DEVELOPMENT OF THE CHICKEN EMBRYO

Materials. Same as those of the preceding project.

Procedure. Start the incubator with only one egg, and add an egg each day for twenty-one days. Each egg will then be a day older than the next one added. On the last day open all the eggs. This will show all the stages of development at once. Keep all the specimens in a physiological salt solution at about 98° F. during the time the embryos are on exhibit.

GUIDE QUESTIONS FOR STUDY. REPRODUCTION

[Text pages 570–572]

1. Name at least two organisms which reproduce sexually yet have no special sex organs.

2. Name at least two which are hermaphroditic, that is, which have both male and female sex organs in the same organism.

3. Name at least two belonging in phyla below the chordates, of which each individual is either male or female.

GUIDE QUESTIONS FOR STUDY. REPRODUCTION

[Text pages 573–578]

1. Why do lower organisms need to be more prolific than higher organisms?

2. Contrast the development of the embryo plant with that of an embryo higher animal.

3. List in order the stages in the development before birth of all higher animals. Use two columns.

4. In what ways are the embryos of plants and animals protected?

5. How do these means of protecting the embryo aid the species to survive?

Problem. What are some characteristic structures of the moss plant?

Materials. If possible, living specimens; if not, preserved or dried specimens of moss, including the entire plant; compound microscope.

Procedure and observations. Separate the moss plants so that you have single plants which have both the leafy base and the stem and capsule growing from the top of the leafy base.

Remove a leaf from one of the plants, and examine it under the low-power objective of the microscope. Does it have veins? _______ In the space at the bottom of the page make a sketch of it, showing its structures as you see them.

Examine under the microscope the tips of the branches of the leafy part of a moss plant that does not bear a stem and capsule. Can you find any very small structures which are clearly different from the leafy structures about them? These are the sex structures of the moss plant. They may be either male or female, since both male and female sex organs may be found on the same leafy plant.

Remove the tip from the spore case at the tip of the stem-like structure which grows from the leafy plant. If it is a ripe spore case, or sporangium, you may be able to dust out on a microscope slide some of the spores. If you can, examine them under the high power of the microscope, and sketch what you observe.

Examine the root system of the leafy plant. As compared with other mature plants with which you are familiar, is the root system of the moss plant well developed or poorly developed?

____

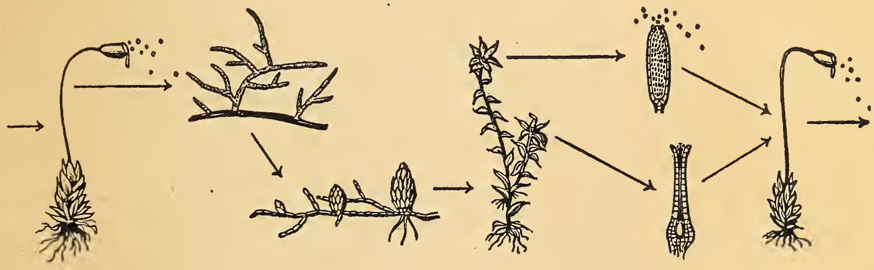


Fig. 2

Read pages 578–579 of *Everyday Biology*. The figure on this page illustrates the various stages in the life history of the moss plant. Label the various stages in the figure. Your labels should include these terms: *asexual generation*, *sexual generation*, *sporophyte*, *female sex organ*, *male sex organ*, *gametophyte*, *young leafy plant.*

Problem. What are some of the stages in the development of a fern plant?

Materials. Some ripe fern sporangia; porous earthen brick; pan of water; microscope; hand lens; slide and cover glasses.

Procedure and observations. Put a number of spore cases on the microscope slide, and observe them through the low-power objective of the microscope. If they are thoroughly ripe, you will observe them open.

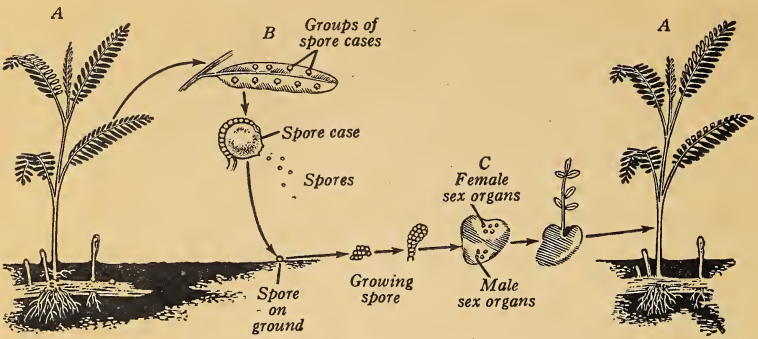


Fig. 3. Life cycle of fern

Briefly describe how they open.

Immerse the brick in water; then hold one of its wet surfaces close to the leaves of a fern plant having ripe sporangia. Shake the leaf to make sure that some of the spores light on the brick. Stand the brick with one end in a dish containing two or three inches of water. Keep the dish and the brick in a warm place which is neither in direct sunlight nor in darkness. Observe the brick surface from day to day. See whether you can discover and examine with your hand lens the various stages of development shown in the figure on this page. Make a sketch of each stage you observe, and beside each sketch write the date upon which you observed it.

NAME____ DATE__________________

GUIDE QUESTIONS FOR STUDY. ALTERNATION OF GENERATIONS

[Text pages 578–581]

Explain the meaning of "alternation of generations" of plants, using these terms: *sexual generation, spore, gametophyte, sporophyte, sporangium, asexual generation, gametes.*

GUIDE QUESTIONS FOR STUDY. REPRODUCTION

[Text pages 581–590]

1. List ways in which migration aids in survival.

2. List ways in which hibernation aids in survival.

3. Name the animals that you know build nests for their young.

Self-test on Biological Terms. Be sure you can define these words. Check your definitions with those in the Glossary of your textbook.

alternation of generations
calyx
conjugation
corolla
cross-pollination
embryo
fertilization
flower
gamete
hibernation
life history
migration
petal
pistil
pollen
pollen tube
pollination
self-pollination
sepal
stamen

Exercise on a Scientific Principle. What evidence can you state in support of this principle: "In general, the higher an animal is in the scale of life, the greater is its need of parental care"?

GUIDE QUESTIONS FOR STUDY. FACTORS OF INHERITANCE

[Text pages 591–598]

1. Name five variations which might be found in leaves of the same tree, ears of corn, or children in the same family.

2. Occasionally people are born with six fingers or six toes. How could it be determined whether such an individual is a mutant or a freak?

3. What is a hybrid?

4. If you wanted to produce a new variety of apple, would you do it by crossbreeding or by grafting? ------------------ Explain.

Special Reports. Prepare a ten-minute talk to be given in class on one of the following topics. Write your notes in the space at the bottom of this page or on a separate sheet.

1. The methods used by Luther Burbank in producing new plants, and some of the more interesting and valuable plants he produced.
2. Describe twenty desirable plants or animals which have been developed by man from less desirable kinds.

NAME____ DATE__________________

EXPERIMENT 101. MITOSIS

Problem. What are the stages in the process of mitosis?

Materials. Prepared slides of onion root tip or of *Ascaris*.

Procedure and observations. Examine the specimens to find as many as possible of the successive stages shown in the figure on page 601 of *Everyday Biology*. Number on the figure on this page the successive stages in cell division. Also sketch in the space at the right of the figure any stages you find on the slides which seem intermediate between those given in the figure on page 601 of the textbook.

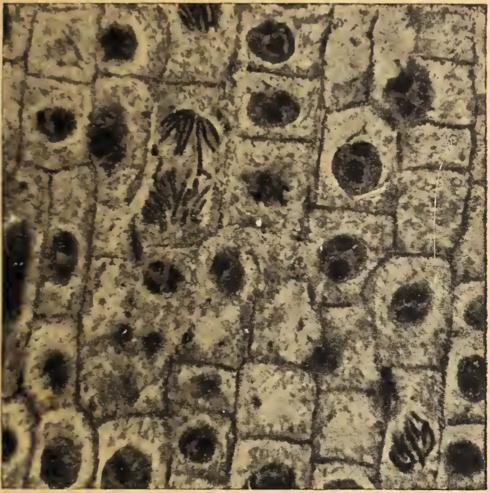


Fig. 1. Section of onion root tip photographed through microscope

CLASS EXERCISE. VARIATION

Problem. What variations in any given character are to be found among the members of the class?

Procedure. 1. Each pupil should first study his own characters. Consider the ones given below and any others you wish to add.

Color of eye ____________________________

Color of hair ___________________________

Hair straight or curly ____________________

Height _________________________________

Length of middle finger __________________

Length of nose _________________________

Weight _________________________________

____

2. Choose some one character, such as height, for further study. Collect the measurements obtained by each member of the class. Arrange these figures in order from the shortest to the tallest.

(For fractions use the nearest whole number.) Then make a graph similar to the one on this page to show the variations of this character within the class group. Write headings and legend for Fig. 3.

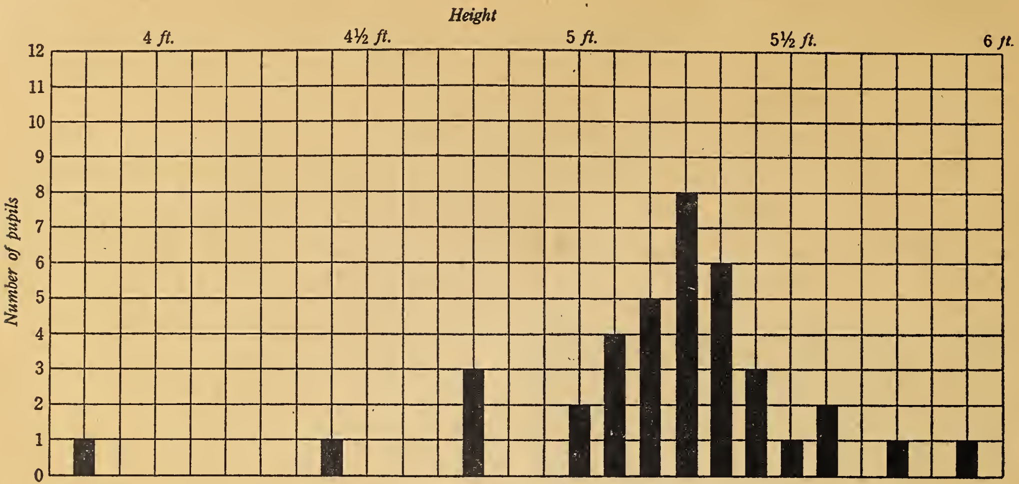


Fig. 2. Variations in the heights of the 38 members of a class. The shortest member was 3 ft. 10 in. tall. Eight members were 5 ft. 3 in. tall. How tall was the tallest member? _______.

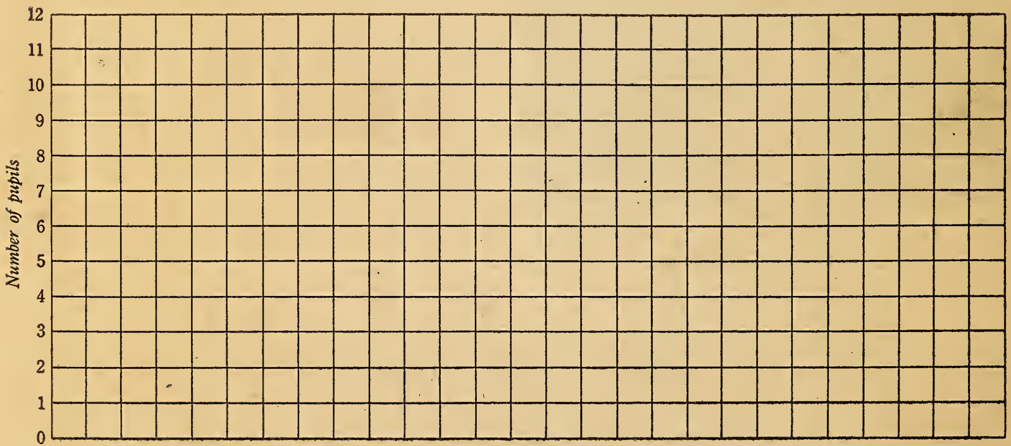


Fig. 3.

STUDY EXERCISE. MENDEL'S LAWS

[Text pages 603–607]

Problem 1. What will be the character of the offspring if purebred parents are unlike in some one character?

Procedure. Color is a convenient character to use in this problem. In guinea pigs black color of hair is dominant over white color. Fig. 4 on page 187 indicates a purebred black guinea pig mated with a purebred white one. Write the color of each offspring below the offspring. Are the offspring purebred or hybrid? ____________ Explain.

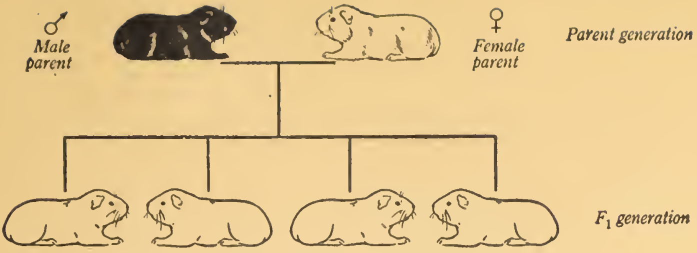


Fig. 4

The same facts shown in Fig. 4 may be represented by letters, as in Fig. 5. Below each offspring of the F_1 generation in Fig. 5 write the color of the offspring.

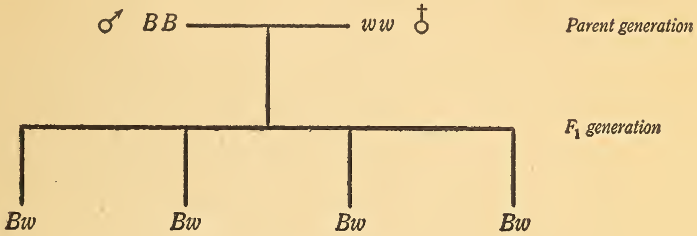


Fig. 5

The simplest method of determining what characters the offspring will inherit is to use a square like Fig. 6. The male parent has genes for black color only. The female parent has genes for white color only.

In the offspring shown in Fig. 6 some of the reproductive cells have genes for -------- color, and some have genes for -------- color. But the color of the hair of every one of the offspring is -------- because that is the dominant color.

♂ ♀	B	B
w	Bw	Bw
w	Bw	Bw

Fig. 6

Problem 2. What will be the characters of the offspring if two hybrids are crossed?

Procedure. Complete the diagrams (Figs. 7 and 8) to show the color of the hair of the offspring of two of the hybrids shown in Problem 1.

Write labels under the figures in Fig. 7 to show whether each is black or white, and purebred or hybrid.

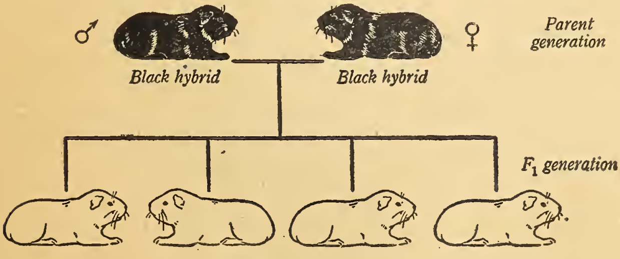


Fig. 7

♂ ♀	B	w
B		
w		

Fig. 8

Problem 3. What are the characters of the F_1 and F_2 generations if the original parents are purebreds with one contrasting character?

Procedure. In guinea pigs rough coat is dominant over smooth coat. Complete Fig. 9 to show the types of coat in F_1 and F_2 generations. Draw wavy lines to indicate rough coats, as in Fig. 10. Use the squares to determine whether each guinea pig is rough or smooth.

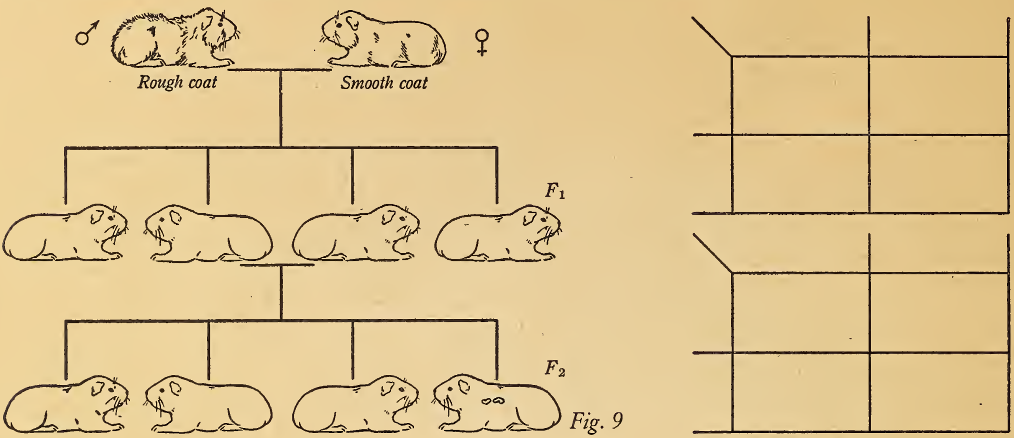
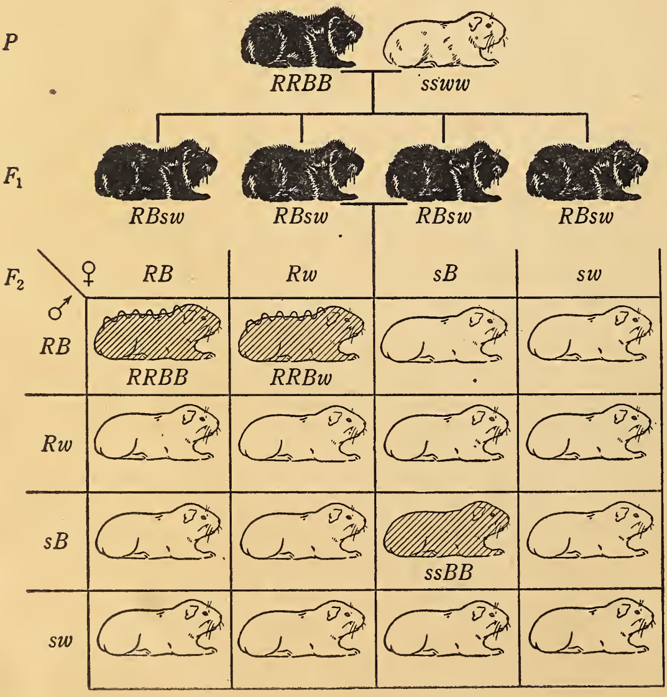


Fig. 9

Problem 4. What will be the characters of the F_1 and F_2 generations if the original parents differ in two characters?

Procedure. If a purebred guinea pig having a rough black coat is mated with one having a smooth white coat, all the offspring (F_1 generation) will have rough black coats. Explain why.

Complete Fig. 10 to show the characters of the F_2 generation. Use shading to show black, and wavy lines to show rough coat.



Parental generation
Pure-bred—rough black (RRBB)
or smooth white (ssww)

F_1 generation
Hybrid—rough black (RsBw)

F_2 generation. How many will have the following characters?

(1) Black rough coats ________

(2) Black smooth coats ________

(3) White rough coats ________

(4) White smooth coats ________

Which types in the F_2 generation are different from any in either the P or the F_1 generation?

Fig. 10

Complete the diagram of imaginary animals (Fig. 11) to show the characters of the F_2 generation. Assume that the F_1 generation indicates which characters are dominant.

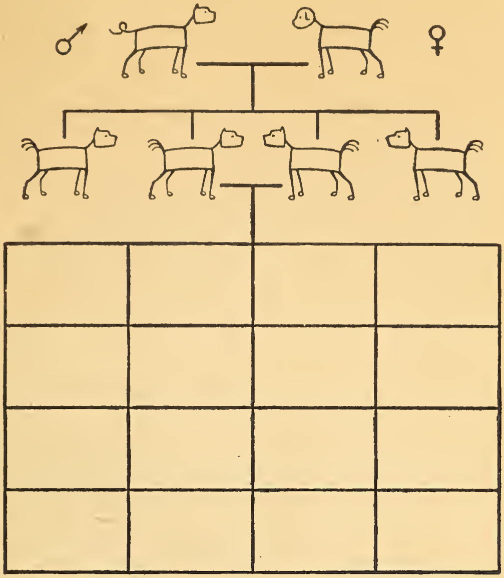


Fig. 11

PROJECT 36. TO DETERMINE SOME OF THE LAWS OF INHERITANCE

Procedure. Breed several pairs of purebred black with purebred white guinea pigs. Record the number of white and of black offspring.

When the offspring are mature, breed them, and again record the number of white and of black offspring.

From your results what do you conclude with respect to the comparative numbers of white and of black guinea pigs to be expected in the first generation of offspring?

In the second generation of offspring?

GUIDE QUESTIONS FOR STUDY. HEREDITY

[Text pages 598–608]

1. Study the figure on page 601 in the textbook. Why are the two cells formed by mitosis like the original cell?

2. What relation have genes to chromosomes?

To inheritance?

3. Draw a cell with six chromosomes. Number these chromosomes from 1 to 6, and show by diagrams how these chromosomes are distributed in the process of division if the cell is a reproductive cell.

4. Select from the "Study Exercise," pp. 186–188, facts which illustrate Mendel's law of dominance.

Which illustrate Mendel's law of segregation, that is, that in succeeding generations the characters appear in different combinations, provided one or both parents are hybrids?

EXPERIMENT 102. PRACTICAL APPLICATIONS OF THE LAWS OF INHERITANCE

Problem. Can desirable and undesirable characters be inherited?

Materials. The "family trees" given on this page.

Procedure and observations. For a background read pages 611–613 of *Everyday Biology*. Examine the figure on this page. Here we have four studies in heredity: (1) the marriage of a normal man with a feeble-minded woman; (2) the marriage of two feeble-minded persons; (3) the marriage of two normal persons; and (4) the marriage of a normal woman with an alcoholic man who was the son of a feeble-minded woman.

How many of the children of marriage (1) are known to be of normal intelligence? ______ Is any of these defective in any other way?

How many of the children of marriage (2) were normal? ____________ What percentage of those who did not die in infancy were feeble-minded? ____________ How many of the children of marriage (3) are known to be normal? ____________ How many are known to be abnormal? ____________ How many children of marriage (4) were normal? ____________ Do the nine children indicate that theirs was healthy stock? ____________ Explain.

Does the evidence in this figure indicate that if one parent is feeble-minded, some of the children (*a*) will not be, (*b*) will probably be, (*c*) will almost certainly be, or (*d*) will certainly be feeble-minded?

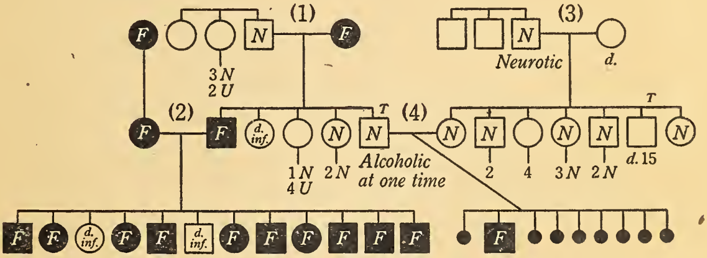


Fig. 12. Recessive character of feeble-mindedness and effects of alcoholism

Small black circles indicate stillbirths; d., died; d. inf., died in infancy; T, tubercular; U, unknown. After Goddard

What evidence in this figure indicates that if both parents are feeble-minded, most of the children will be normal or feeble-minded?

What evidence here seems to indicate that alcoholism is a defect which is likely to prevent parents from having normal children?

What evidence is here that an apparently normal person may carry the genes of feeble-mindedness and that therefore feeble-mindedness may appear in the next generation?

What evidence here indicates that it is necessary to know not only the person one wants to marry but also the family of that person before one decides to marry?

EXPERIMENT 103. INHERITANCE IN HUMAN BEINGS

Problem. Are desirable as well as undesirable characters inherited?

Materials. The facts presented in Fig. 13.

Procedure and observations. The figure shows four different family trees, the first of a superior family, the others with different kinds of defects. Make a list of questions similar to those in Experiment 102, but based upon the evidence in the figure, which you think bring out the important lessons that these studies present. Two such questions might be these: How many of the children of the two pairs of parents in 1 were talented? Were more or fewer of these children talented than were not?

When you have completed your list of questions, exchange with one of your classmates to see whether each can answer the other's questions.

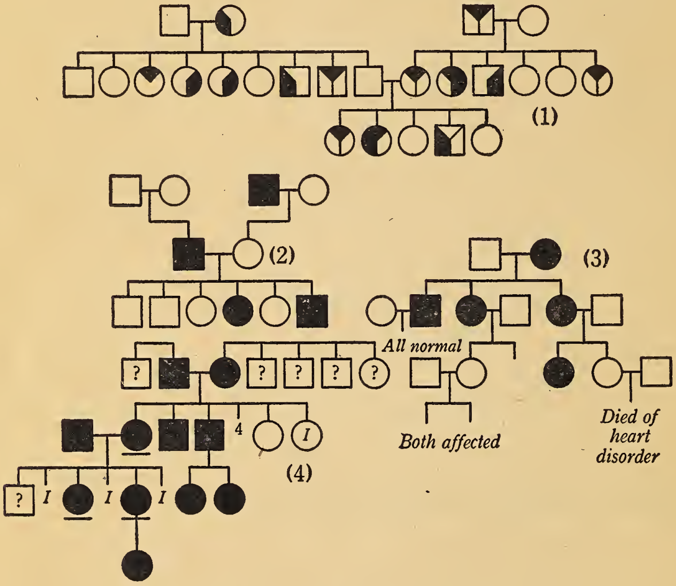


Fig. 13. Heredity of human traits

Squares represent males; circles represent females. 1, pedigree of a family showing artistic (dark upper portion), literary (right section), and musical (left section) ability; 2, family with digestive troubles; 3, family with heart disorders; 4, family with feeble-mindedness (I, died in infancy; ?, uncertain mental condition). From Gruenberg's *Elementary Biology* (1, 2, 3, after Davenport; 4, after Goddard)

PROJECT 37. TO MAKE MY OWN FAMILY TREE

Procedure. Make a study of your own family similar to these studies. Find out all the facts you can about your parents and their brothers and sisters, about their parents (your grandparents), and about yourself and your own brothers and sisters. Carry this record back for as many generations as you can, making sure that the information you have is as accurate as possible. Make separate "trees" for different traits which you wish to trace. Try to find out the undesirable traits as well as the desirable ones. Every family is sure to have some members with undesirable traits of one sort or another.

Draw your "trees" on a separate sheet to be put on the bulletin board. Use a plan similar to that used in the figures on pages 191 and 192 of this workbook.

PROJECT 38. TO MAKE POSTERS SHOWING NEW VARIETIES OF PLANTS AND ANIMALS

Procedure. From seed catalogues, magazine advertisements, and special magazines secure pictures and descriptions of new varieties of vegetables, flowers, pets, fish, or poultry. Mount these pictures and their descriptions on a large cardboard. Prepare a ten-minute report on your exhibit, to be given to your classmates.

GUIDE QUESTIONS FOR STUDY. PLANT AND ANIMAL BREEDING

[Text pages 609–616]

1. How would a plant-breeder proceed to produce a new breed of corn which would be resistant to smut? List the steps in his procedure.

2. How would a stockman proceed to improve his herd of beef cattle?

3. What is a pedigree?

Self-test on Biological Terms. Be sure you can define these words. Check your definitions with those in the Glossary of your textbook.

character
chromosome
dominant character

gene
hybrid
mutant

mutation
recessive character
variation

NAME____ DATE________________

PROBLEM. TO GATHER FACTS ABOUT PRIMITIVE MAN

Problem. What are some important facts about ancient man which have been learned from a study of his fossil remains and of his implements and handiwork?

Materials. Encyclopedias, and such other books relating to primitive man as can be secured.

Procedure. Locate your material in the indexes of the books; then prepare your class report in accordance with the outline for a discussion which is given on page ix of the section "How to Study" in *Everyday Biology.* Topics for discussion include these: The Cro-Magnon Man, The Java Man, The Piltdown Man, The Neanderthal Man, The Art of Ancient Man, The Weapons of Ancient Man, The Old Stone Age, Animals Now Extinct Which Ancient Man Knew, The New Stone Age, The Bronze Age, Stonehenge, The Mound-Builders of America, The Cliff Dwellers of America. You will find discussions of some of these topics in encyclopedias under the general title "Archaeology."

A sample outline for your notes on one of these topics is given here. Record your brief notes under these headings.

I. What is it? (State with a short description the object you are discussing.)

II. What is its history? (In this case you would include here the third step in the outline (p. ix, *Everyday Biology*), namely, where the object or objects were found.)

III. What are its most important characteristics—those which distinguish it from everything else?

Draw on a separate sheet, for the bulletin board, any sketches you may wish to copy.

PROJECT 39. TO MAKE A CHART SHOWING PLANTS AND ANIMALS OF THE VARIOUS GEOLOGICAL AGES

Procedure. Probably all the members of the class will want to work together on this project.

On a long sheet of wrapping paper lay out spaces corresponding to the spaces shown in the figure on page 622 of *Everyday Biology*. Label each space with the name of the age it represents. Consult encyclopedias and books on geology and ancient life for pictures of plants and animals belonging to the various geological periods. Sketch these on paper, cut out the sketches, and paste them in their proper places on the strip.

GUIDE QUESTIONS FOR STUDY. FOSSILS

[Text pages 617-623]

1. What are the various types of fossils?

2. List evidence which tends to prove that present living things are descended from those of earlier times.

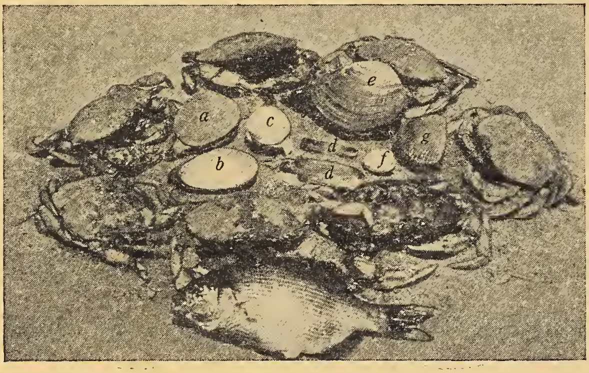
Exercise on Biological Principles. Select one or more of the biological principles given on pages 626-627 of the textbook, and state here your evidence supporting it.

PROJECT 40. TO CORRELATE VACATION EXPERIENCES WITH BIOLOGICAL MATERIALS AND ENGLISH

Some of your most interesting themes for English classes can be written about your "Vacation-Time Biology." In *Everyday Biology* (pp. 11, 160–161, 293, and 435) are examples of such themes. If you keep a diary or a notebook in which you jot down your experiences with living things and your observations of them, you will have a wealth of material not only for English themes but also for science-club and assembly talks and for discussion in social-science and other classes. You can add to the interest in these materials by illustrating them with your own snapshots or other pictures which you collect on your trips.

Here is a typical English theme written about "Vacation-Time Biology."

A CLAMMING EXPEDITION



Some of our Catch

The clams are (*a*) quahog, (*b*) and (*c*) Eastern clams, (*d*) razor clams (Bob dug these later on the ocean beach), (*e*) Washington clam, (*f*) little-neck, and (g) cockle. Tom caught the fish off the old dock. It is a porgy.

How should you like to go "clamming" on an Oregon bay? First of all you must consult the tide books in order to be sure to choose the best time. We will choose one of the spring tides, of course, at new moon or full moon, when the tides will be lowest. We find that extreme low tide will occur at about daybreak. We shall therefore need to have everything in readiness the night before in order to be off before dawn. But that is part of the fun.

Dressed in our oldest clothes and equipped with rakes and long-handled spades and shovels, and with gunny sacks in which to carry the clams, we arrive at the wharf where the old fisherman is already in his boat awaiting us. We climb down the landing ladder carefully, for it is covered with slippery seaweed. We are in time, for the tide is still ebbing fast. We jump into the boat and are admonished by the "skipper" to "sit down and trim ship."

The "skipper" unties the painter of the boat, starts his gasoline engine, and we are off. It is two miles across the bay to the clam flats; and we are glad we put on heavy clothing, for it is cold. It is beginning to get light now, and we can see the black flats ahead.

Eagerly we jump out on the firm sand. Some of the girls take the rakes and look for cockle clams. They are told to rake wherever they see two little holes close together, for this clam is just below the surface. "I've found one," somebody shouts, "but it has closed its shell on the tines of the rake and I can hardly get it off." "See what I've found," another shouts excitedly as she rakes from the seaweed in a shallow pool a big crab with its eight legs and two claws waving indignantly.

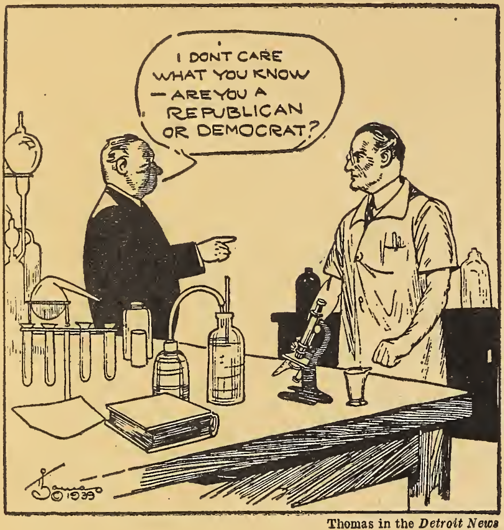
The boys with their spades and shovels are after other game. They are told to poke a finger into each hole they see; if something moves down into the hole at their touch, leaving water in the hole, it is probably the siphon of a clam. Each selects a hole and begins to dig. They throw out the heavy sand in shovelfuls, and without caution, until the hole is nearly a foot deep. Then the shovel grates on shell. "I've got him," shouts one. "Not yet, you haven't," says the "skipper", who is superintending operations. "Now, not too fast. Dig to the side, and don't pry against the shell or you'll break him. Careful, now! That's right. Now reach in and get him." The boy, groping in the sand and water at the bottom of the hole, soon gets his hand around the clam and tugs. "There, isn't that a beauty?" he shouts as he displays a lusty quahog bigger than his fist. Other members of the party have by now captured quahogs and some Washington clams, which are still larger.

Forty minutes pass. The tide now is flooding and is driving the diggers to the highest parts of the flat, which will soon be entirely covered. "Time to go," shouts the skipper. Everybody carries his clams to the water, washes them, and puts them into the gunny sacks. The girls have a substantial pile of cockles near by, and these with several crabs are sacked, too. The gunny sacks bulge comfortably, and aren't they heavy — and wet!

We wade knee-deep to the boat and scramble in. Our feet have been wet since we first landed on the flats, and our shoulders are wet, too, where the sacks touched them when we carried the clams to the boat. It was hard work; we find ourselves tired. Tomorrow we shall be lame from the unusual exercise. But what fun it was! We realize now how hungry we are; it is pleasant to think of the fried and baked clams, the fritters, the clam soup, and clam chowder we shall have later. But meanwhile what a breakfast we are going to eat, just as soon as we get back across the bay!

PROJECT 41. TO DRAW CARTOONS ILLUSTRATING THE SCIENTIFIC ATTITUDES AND TO POINT OUT SOCIAL IMPLICATIONS

Procedure. On pages 624–625 of *Everyday Biology* is a list of "Scientific Attitudes." Draw cartoons illustrating one or more of these scientific attitudes. The cartoon on this page illustrates No. 8. Write beside it the attitude it illustrates, and write also a brief statement of its social implications if these are evident. Make your first drawing on this page. After you have revised it until it represents your idea in a satisfactory way, copy it on a drawing sheet to be put on the class bulletin board.


I DON'T CARE WHAT YOU KNOW — ARE YOU A REPUBLICAN OR DEMOCRAT?
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Thomas in the *Detroit News*

PROJECT 42. TO STUDY SCIENTIFIC ATTITUDES THROUGH ADVERTISING

Procedure. Collect statements from magazine, radio, and newspaper advertising which you think would appeal (1) to those who possess scientific attitudes and (2) to those who do not possess scientific attitudes. Write or cut out the statements and paste them on a large sheet of cardboard. Beside each write the scientific attitude (see pages 624–625 of *Everyday Biology*) which most closely applies to the statement. The cardboard sheet will make a valuable permanent addition to your school and classroom exhibits.

LEISURE READING

On pages 650 and 651 of your textbook is a list of interesting books on a wide variety of biological subjects. The reading of one of these, or another book dealing with some aspect of science, would afford pleasant recreation and would at the same time supplement in a profitable way your study of biology. Here is a brief and convenient form of book report which has been developed with students in high-school science classes.

BOOK REPORT

Title of Book --

Author --

Answer as many as you can of the following questions by underlining part of each question inclosed in parentheses:

1. Did the general appearance of the book, its cover, its pages, its pictures, and so forth, make you want to read it? (Yes · No)
2. Did you find the book (*very* easy · easy · difficult · *very* difficult) to read?
3. Did the book add (*very* little · little · much · *very* much) to your knowledge of scientific facts?
4. Would you recommend it to some other student to read? (Yes · No) If not, state briefly why.

If so, would you recommend it because it was chiefly interesting to you, or because of the valuable and useful facts you learned from it, or both because you found it interesting and because it gave you valuable information?

5. Did you read the book straight through, or did you skip and skim through it?
6. Did you read this book since school began this term? (Yes · No)

7. State here very briefly the most interesting or most valuable scientific fact you learned from the book.

BOOK REPORT

Title of Book --

Author --

Answer as many as you can of the following questions by underlining part of each question inclosed in parentheses:

1. Did the general appearance of the book, its cover, its pages, its pictures, and so forth, make you want to read it? (Yes · No)

2. Did you find the book (*very* easy · easy · difficult · *very* difficult) to read?

3. Did the book add (*very* little · little · much · *very* much) to your knowledge of scientific facts?

4. Would you recommend it to some other student to read? (Yes · No) If not, state briefly why.

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5. Did you read the book straight through, or did you skip and skim through it?

6. Did you read this book since school began this term? (Yes · No)

7. State here very briefly the most interesting or most valuable scientific fact you learned from the book.

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